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How do Children Spend their Time?

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How do Children Spend their Time?


by

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Thesis

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Dedication

Dedicated to my lovely husband Humberto, our two wonderful daughters Isabella and Livia, to my parents Marcos and Solange and my siblings Alessandra and Rodrigo.
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Abstract

How do Children Spend their Time?
A Quantitative Analysis of Physical Activity in
Children on the Autism Spectrum.

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Autism spectrum disorder (ASD) is pervasive neurodevelopment disorder characterized by a broad range of social abnormalities and deficit in motor skills, many times referred to as clumsiness. These abnormal social characteristics result in a restricted repertoire of activity and interests that also may affect the motor learning process. Therefore, fewer opportunities to practice motor skills can lead to a delay in achieving motor proficiency. It is well known that physical activity and motor proficiency are positively correlated and the amount of time spent in a physical activity is directly related to the level of expertise in neurotypical children. Hence, the specific aim of this study is
to quantify the amount of physical activity in children with ASD and compare this value to that of non-diagnosed siblings (ASD siblings) and neurotypical controls (NT), as well as to compare the amount of physical activity between neurotypical controls and ASD siblings.

In this study, it was hypothesized that: 1) children with ASD would have lower scores than their non-diagnosed sibling and also than the NT controls in the amount of physical activity; 2) non-diagnosed siblings and neurotypical children would not be different in the amount of physical activity; 3) children with ASD’s general score on the motor skills assessments would be lower than the non-diagnosed siblings and lower than NT controls; 4) There would not be a difference in the general score on motor skills assessments between non-diagnosed siblings and neurotypical children and 5) the motor assessments scores would be positively correlated (p < 0.05) to the amount of physical activity.

There were differences between ASD and NT groups regarding to the amount of physical activity and also regarding to the motor proficiency scores. Although those differences were not statistically significant, they definitely are clinically relevant as showed that the children on the autism spectrum presented a clear motor delay. Likewise, the correlation between amount of physical activity and motor proficiency was showed not to be significant. These results can be explained by the small sample size. Further studies with a larger sample size would be crucial to verify these hypotheses proposed in the present study.
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Chapter 1: Introduction

Autism spectrum disorder (ASD) is a complex, severe and pervasive neurodevelopment disorder characterized by a broad range of social abnormalities and language deficits. These impaired social and communication skills of children with ASD are thought to be sources of the failure to develop appropriate peer relationships. The lack of awareness of others contributes to deficits in the learning processes because observation (mirroring others) is an important piece in the process of learning new social, communication and motor skills. The result is a restricted repertoire of activity.

A child’s consequent isolation or the limited (sometimes non-existent) interest in establishing social interactions creates fewer opportunities to practice motor skills, leading to a delay in achieving motor proficiency. The impairment of observation skills associated with isolation is also thought to contribute to the inappropriate learning of motor skills (American Psychiatric Association, 1994; Hadjikhani, Joseph, Snyder, & Tager-Flusberg, 2006; Hamilton, 2008; J. H. G. Williams, et al., 2006; J. H. G. Williams, Whiten, Suddendorf, & Perret, 2001). Thus, the practice of motor skills in the early years of childhood is crucial, since these skills are the building blocks to acquire more specific and complex motor skills in later childhood. Physical activity and motor proficiency are positively related and this correlation is well known (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). The practice of new motor skills is responsible for smooth and well coordinated movement; therefore the amount of time spent in a physical activity is directly related to the level of expertise in neurotypical children. Hence, the specific aim of this study was to quantify the amount of physical activity performed by children with ASD and compare this value to that of neurotypical children. The group of neurotypical
children was subdivided into non-diagnosed siblings of those on the autism spectrum (ASD-sib), and non-related children. These groups allowed us to compare activity levels between children on the spectrum and non-diagnosed children as well as to investigate the influence of the home environment on activity by comparing non-diagnosed siblings with non-related neurotypical children. The amount of physical activity is defined in this study as the percentage of time spent engaged in moderate–to-vigorous physical activity (MVPA).

The age range for this study was 5 to 10 years of age. The minimum intelligence quotient (IQ) score required was 70 and was verified using the Kaufman Brief Intelligence Test (K-BIT). The Bruininsky-Oseretsky Test of Motor Proficiency - Second Edition (BOT-2) and the Movement ABC – Second Edition (MABC-2) assessments were used to determine the presence of any motor delay, determining the children’s age equivalence for each subtest. Three other methods were used to quantify the physical activity in the two groups: diary checklist of physical activity (parental report) concomitantly with the use of an accelerometer device. The questionnaire provided a list of activities and the time that the children spent during each activity and the intensity was based on METs (metabolic equivalents) for each of the activities. These METs were pre-established and reported in a compendium of physical activity that coded each activity based on energy expenditure (EE). For a subset of children, a video recording of the children in their house was done as an additional measure of physical activity to help assess the congruence between the parent report and the accelerometer data.

In this study, it was hypothesized that: 1) children with ASD would have lower scores than their non-diagnosed siblings and the NT controls on the two measures of physical activity (diary checklist of physical activity and accelerometer recordings); 2) siblings of children with ASD and neurotypical children would not be different on the two measures of physical activity.
(diary checklist of physical activity and accelerometer recordings); 3) general score of children with ASD on the motor skills assessments (BOT-2 and MABC-2) would be lower than the non-diagnosed siblings and lower than neuro-typical controls; 4) There would not be a difference in the general score on motor skills assessments (BOT-2 and MABC-2) between siblings of children with ASD and neurotypical children and 5) the BOT-2 and MABC-2 general scores would be positively correlated (p < 0.05) to the two physical activity variables (diary checklist scores and accelerometer data).

**Definition of Terms**

**Actigraph GT3X:** specific brand of accelerometer that collects motion data on three axes.

**ASD:** Autism spectrum disorder.

**ASD sib:** Neurotypical siblings of children with ASD.

**BOT-2:** Bruininsky-Oseretsky Test of Motor Proficiency - Second edition.

**Clumsiness:** Because of the indiscriminate use of this term in other research, this term will be used in this study as synonymous of motor incoordination.

**EE:** energy expenditure.

**Intensity of exercise:** Light intensity- less than 3 METs; Moderate- 3 – 6 METs; Vigorous exercise intensity- greater than 6 METs.

**K-BIT 2:** Kauffman Brief Intelligence Test – Second edition.

**M-ABC-2:** Motor Assessment Battery for Children – Second edition.

**MET:** Metabolic equivalent – defined as the ratio of work metabolic rate to a standard resting metabolic rate of 1.0 (4.184 kJ).kg\(^{-1}\).h\(^{-1}\). 1 MET is considered a resting metabolic rate obtained during quiet sitting.

**MVPA:** Moderate to Vigorous Physical Activity.
NT: Neurotypical.

P.A.: Physical activity

PDD: Pervasive developmental disorder.

PDD-NOS: Pervasive developmental disorder not otherwise specified.

Amount of physical activity: defined by percentage of time spent engaged in physical activity.
Chapter 2: Literature Review

The autism spectrum is comprised of complex, mild-to-severe, pervasive neurodevelopment disorders characterized by a broad range of social abnormalities, language deficits and deficiencies in motor skills (American Psychiatric Association, 1994; Ming, Brimacombe, & Wagner, 2007; World Health Organization, 1992). ASD is usually diagnosed between the ages of 2 and 3 years and is three to four times more prevalent in boys than girls (Hadjikhani, et al., 2006; World Health Organization, 1992). Autism spectrum disorder (ASD) is part of a group of disorders of psychological development under the umbrella of Pervasive Developmental Disorder (PDD). The PDD group also includes other disorders such as Asperger’s syndrome, Rett’s syndrome, pervasive developmental disorder not otherwise specified (PDD-NOS) and others (American Psychiatric Association, 1994; World Health Organization, 1992).

The majority of those on the spectrum present with significant motor dysfunction including delays in milestones, postural instabilities, poor balance, abnormal gait patterns, poor tool use, as well as deficits in imitation/mimicry, and poor motor coordination. Overall, there is an inability to initiate, switch, efficiently perform or continue ongoing action (Damasio & Maurer, 1978; Gowen, Stanley, & Miall, 2008; Hamilton, 2008; Jones & Prior, 1985; Kohen-Raz, Volkmar, & Cohen, 1992; Larson, Bastian, Donchin, Shadmehr, & Mostofsky, 2008; Manjiviona & Prior, 1995; Mari, Marks, Marruffa, Prior, & Castiello, 2003; Teitelbaum, Teitelbaum, Nye, Fryman, & Maurer, 1998; Vilensky, Damasio, & Maurer, 1981). In fact, Teitelbaum et al. (1998) demonstrated that the movement disturbance, in the case of the milestones of development, were clearly detected long before the diagnosis of autism.
Teitelbaum observed motor incoordination during specific tasks (e.g. lying, sitting, crawling, and walking suggesting insufficient neuromotor development.

Children on the autism spectrum are well known for performing poorly on tasks requiring an understanding of the mental states of others (Theory of Mind), abnormal imitation and emotion processing. The observation of human movement influences the observer’s own motor system (Gowen et al., 2008) and imitation can be a core cognitive process required for the development of motor skills and social cognitive ability. Impairment in observational skills during infancy may reflect a neurological deficit associated with autism spectrum disorders (American Psychiatric Association, 1994; Hadjikhani, et al., 2006; Hamilton, 2008; J. H. G. Williams, et al., 2006; J. H. G. Williams, et al., 2001). Therefore, all these characteristics can be translated into a deficient and/or nonexistent social interaction and lead to the consequent isolation often observed in children with ASD.

Social interaction and communication skills in children with ASD are also abnormal or impaired and may be responsible for their failure to develop appropriate peer relationships. The lack of awareness of others contributes to diminished learning as observation (mirroring others) is an important piece in the process of learning new social and motor skills (American Psychiatric Association, 1994; Hamilton, Brindley, & Frith, 2007; Lepage & Théoret, 2007; J. H. G. Williams, et al., 2001; World Health Organization, 1992). The majority of studies previously mentioned support the need for future research to clarify the pattern of motor impairments in individuals on the spectrum, suggesting that such identification would be of great value in the diagnosis and characterization of the syndrome itself.

In addition to the social deficits, the autism spectrum disorders present with a large sample of motor dysfunction symptoms including delays in milestones, postural issues, abnormal
gait pattern, poor tool use, deficits in imitation/mimicry, poor balance and motor coordination. There is an inability to initiate, switch, efficiently perform or continue ongoing action (Gowen, et al., 2008; Hamilton, 2008; Kohen-Raz, et al., 1992; Larson, et al., 2008; Leary & Hill, 1996; Manjiviona & Prior, 1995; Mari, et al., 2003; Teitelbaum, et al., 1998; J. H. G. Williams, et al., 2006). Different types of motor skills assessment, such as BOT, Test of Gross Motor Development (TGMD), Peabody Developmental Motor Scales 2nd edition (PDMS-2), McCarron Assessment of Neuromuscular development, Movement Assessment Battery for children (M-ABC), have been used to provide evidence of motor coordination deficits and motor delay/impairment in fine and gross motor skills in children with ASD. Results from all of these assessments agree on the presence of motor delays/motor incoordination in children with ASD (Berkeley, Zittel, Pitney, & Nichols, 2001; Dewey, Cantell, & Crawford, 2007; Dyck, Piek, Hay, & Hallmayer, 2007; Ghaziuddin & Butler, 1998; Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994; Green, et al., 2002; Green, et al., 2009; Page & Bouchert, 1998; Provost, Heimerl, & Lopez, 2007).

The impairment of motor skills is consistently reported in children with on the autism spectrum; however, the neurological mechanisms are not well established. It has been suggested that children with ASD might have an abnormal mirror neuron system (MNS), which seems to have an important role in the process of learning new motor skills (Hamilton, et al., 2007; Lepage & Théoret, 2007; J. H. G. Williams, et al., 2001). Other studies have implicated the cerebellum in autism spectrum disorders. The cerebellum is involved in attention, learning, anticipation and motor behavior. Allen, Müller and Courchesne (2004) demonstrated that there is a dysfunction in cerebellar activation during simple motor tasks in children with ASD. Rinehart et al.(2006) showed, using an advanced gait analysis system, that motor disorders presented by
children with ASD are related to cerebellar and basal ganglia dysfunction. Courchesne et al. (1994) used MRI to assess the degree of cerebellar hypoplasia in children with autism. They verified that certain areas of the cerebellar vermis are incompletely developed in children on the autism spectrum. This also supports the view that movement disorders might play a role in autism. However, Hardan, Kilpatrick, Keshavan, & Minshew (2003) performed anatomic magnetic resonance imaging of the basal ganglia during specific motor tests and concluded that the motor deficits in ASD may not be related to anatomical abnormalities of the basal ganglia, but support was found for the role of cerebellum and frontal lobe in such deficits. In summary, the research regarding to the possible causes for the autism disorder remain inconclusive.

The social isolation and deficiency on establishing peer relationships may reflect on the physical activity levels and also reflect on a child’s motor proficiency. The opportunity to engage in, and practice, motor skills is essential in the acquisition of motor competence. The skills learned in early childhood are the building blocks for more specific and complex motor skills. The complex motor skills are honed through practice in search of proficiency (Clark, 2005). The relationship between physical activity levels and motor proficiency is stated by Ericsson (2008) and Wrotniak, Epstein, Dorn, Jones, & Kondilis (2006). Ericsson (2008) demonstrated that deliberate practice leads to expertise and also showed that there is a positive association between physical activity and motor proficiency. Conversely, sedentary activity is inversely associated with motor proficiency. Moreover, it was found in recent studies that physical activity levels in children with ASD were lower than in typically-developing children as observed during school recess periods (Pan, 2008a; Pan & Frey, 2006). Hence, the lack of practice of physical activity may lead to gross/fine motor delay (clumsiness/motor coordination) in children with ASD.
Motor development can be defined as the changes in motor behavior that occur during the lifespan, as well as the processes that underlie these changes (Clark & Whitall, 1989). Motor development is a sequential, cumulative and an age-related process where environmental and organism constraints interacts to determine a final and skillful motor pattern (Clark, 2005; Clark & Whitall, 1989). The constraints could be defined as “a property of organism, environment or task that limits or sets boundaries on movement” (Clark, 1994, p.246). Clark and Metcalfe (2002) elaborated a metaphor to describe the characteristics of motor development: the “Mountain of Motor Development.” The mountain is divided in different periods of the lifespan, where the climbing of the mountain corresponds to the sequential, cumulative and age-related process of development (Clark & Metcalfe, 2002). In 1994, Clark described six major periods in the development of motor skills to help the understanding of the numerous changes that occurs with the motor skills during the lifespan. The periods includes: 1) Reflexive, 2) Preadapted, 3) Fundamental, 4) Context-specific, 5) Skillful and 6) Compensation periods (Clark, 1994, 2005).

The Reflexive period corresponds to the third gestational month and extends until approximately two weeks after birth. The movements in this period are purely reflexive and being so, only specific stimuli can elicit these stereotypical movements. These primitive reflexes include rooting reflex, sucking reflex and many others, the purpose of which is to help ensure the survival of the newborn in the first two weeks of life. The preadapted period corresponds to approximately the second week of life (when the movements are no longer solely reflexive) and finishes around the first year. It is characterized by movements that are common to the species (phylogenic motor skills), for example locomotion and feeding. The preadapted period ends and
the fundamental period begins when independent feeding and locomotion take place (Clark, 2005).

The Fundamental patterns period is characterized by the locomotor and manipulative coordination patterns, which are the foundation for a later emerging specific motor skill. They are also called the “building blocks” for other motor skills because the basic motor patterns will be elaborated to become more specialized as practice increases. Organism constraints are important in this phase, however, the environment constraints, obviously, plays a massive role during the fundamental patterns period. When the skills learned in this phase become more context-specific (around 7 years of age), the next period starts - the context-specific period. In this period, the motor skills are more refined and elaborated and are influenced greatly by the culture surrounding the individual. The cognitive skills are also more mature; the understanding of the performance becomes evident and strategies in sport begin to be implemented (Clark, 2005).

The next period is designated the skillful period. Skillful movement is efficient, versatile and can achieve a goal with maximum certainty, which means that the performance can be reliably repeated. It takes several years of practice in one specific movement to become skillful. Continued practice and experience may take some individuals beyond the skillful level. This stage may be called expertise (Clark, 1994). Ericsson (1996, 2008) and Ericsson & Charness (1994) demonstrated that it takes about ten thousand hours of practice to become an expert.

In summary, movement skills are result of the organism/hereditary, environmental and task constraints. Early experience is critical to the basis or foundation upon which later motor skills are built. The fundamental period can be considered a critical or sensitive period for the reason that it is in that period that the fundamental skills are being learned and practiced. A
deficit in learning or practicing a specific skill in the fundamental phase could potentially generate an inharmonious and asymmetrical movement. For example, if running is not learned properly, the gallop and hop will not be done correctly either. Thus, the mountain of motor development is a metaphor that illustrates the motor development process and the periods within this process through which sequential and cumulative patterns of skill acquisition occur (Clark, 1994, 2005; Clark & Whitall, 1989).

The importance of the fundamental period and its relationship with physical activity.

The skills acquired in this period, as previously mentioned, are the foundation for later acquisition of more complex motor skills (the “building blocks”). These skills are evident during sports, games and physical activities. During this period, the children increase their motor repertoire, which includes gross and fine motor skills. This achievement is not only driven by maturation. In addition is the range of different experiences that contribute to more elaborate and harmonious movement and the new movements employed lead toward the skilled performance. Adolph, Vereijken, & Shrout (2003) showed that practice was more significant than age regarding the improvement of walking skills. This finding reinforced Ericsson’s findings about the relationship between physical activity and expertise. Ericsson (1996; 2008) found that it is necessary to gain ten thousand hours of practice to become an expert and concludes that *deliberate* (not casual) practice leads to expertise (Ericsson, 1996, 2008; Ericsson & Charness, 1994). This concept can be applied to the practice of motor skills during the fundamental patterns period. Fisher et al. (2005) studied the relationship between the fundamental motor skills and the habitual physical activity in young children. They showed that there is a weak but positive
correlation between these two variables, especially when considering moderate to vigorous physical activity (MVPA).

An increasing number of authors agree that children with greater motor skills are more active and tend to be more engaged in physical activity than those with less motor skills. The opposite relationship has also been shown to be true. The relationship between physical activity levels and motor proficiency is well defined. Okely, Booth, & Patterson (2001) aimed to determine the relationship between the participation in organized and non-organized physical activity with fundamental movement skills among adolescents. The results demonstrated the significant association between the fundamental movement skills and adolescents' participation in organized physical activity. Wrotniak et al. (2006) showed a positive association between physical activity and motor proficiency and the inverse association between motor proficiency with sedentary living. They also suggested that new research should be directed toward verifying the motor proficiency among family members, such as parents or siblings, to better understand the possible family factors that may influence the physical activity patterns. Siblings have some genes in common and also share the same family environment. These shared characteristics can influence the development of their motor ability. Recently, Wrotniak, Salvy, Lazarus, & Epstein (2009) explored the motor proficiency relationship among siblings. Although twenty three pairs of sibling were tested, it was found that there was no relationship among siblings with respect to general motor proficiency. However, some specific tasks within the subtests showed a significant correlation among siblings – thus siblings may share some proficiency characteristics.

The association between physical activity and motor proficiency was also reported by Haga (2009) who tested the development of physical activity over time in two groups of children: low motor competence and high motor competence. Haga found that children with low
motor competence have poorer physical fitness when compared with the high motor competence group. In other study, Castelli and Valley (2007) discussed the relationship of physical fitness and motor proficiency and compared these traits to physical activity. They showed that motor competence plays a role in the level of physical activity level. Castelli and Valley stated that due to the “bidirectional nature of the relationship between these variables” it is possible to say that children that are more active show better motor competence (Castelli and Valley, 2007, p.369). Moreover, they reinforced the importance of the fundamental motor skills and their relationship with motor proficiency based on the higher scores on the motor rubrics demonstrated by children with the best motor proficiency. Similarly, in another study conducted on preschoolers, the Castelli and Valley showed the strong relationship between motor proficiency and physical activity behavior, reinforcing that the poorer motor skill, the less was the engagement in physical activity. It has also been demonstrated that children who scored better on motor skills spent 13.4% of their time in moderate-to-vigorous physical activity and 5% in vigorous physical activity (H. G. Williams, et al., 2008).

*Physical activity and Autism.*

Physical activity can be defined as any body movement produced by skeletal muscles that generates energy expenditure” (Caspersen, Powell, & Christenson, 1985). The U.S. Department of Health and Human Services (2008) recommends that children should participate in physical activity for 60 minutes (1 hour) or more each day. This physical activity should include bone and muscle strengthening exercises as well as aerobic activities. The aerobics should be moderate to vigorous intensity and occur daily moreover, the vigorous intensity aerobics should be done at least three times a week. Accordingly to Pate et al. (1995), during the moderate intensity activity
the work metabolic rate/resting metabolic rate (METs) varies from 3 to 6. Therefore, based on Pate’s work (Pate, et al., 1995) and also on the Compendium of Physical Activities (Ainsworth, et al., 2000), the MET intensity of physical activities can be divided in three categories as follow: a) light intensity less than three METs; b) moderate intensity three to six METs; c) vigorous more than six METs.

Although children on the autism spectrum are known by their poor motor performance and lack of engagement in physical activity, the research about physical activity patterns in these children is very sparse. Despite that, a few studies have been published recently showing that children on the autism spectrum are less active than their typically developing peers. Pan and Frey (2006) wanted to identify the patterns of physical activity in youth and relate it to age. They tested 30 youth (ages 10 to 19 years) with diagnoses of Autism, Asperger’s and Pervasive developmental disorder not otherwise specified (PDD-NOS). The youth wore a uniaxial accelerometer for 8 hours per day during 7 consecutive days and completed a recall diary physical activity. They found that children on the autism spectrum were less active than the control group and that the children on the spectrum did not regularly engage in moderate-to-vigorous physical activity (MVPA). Micacchi, Giuliani, Cerbo, Sorge, & Valenti (2006) published a review of literature regarding the physical activity in young patients with autism and concluded that they did not engage in adequate amounts of MVPA during the physical education (only 41% of their time). Although this result was not significantly different from neurotypical group, 41% is still less than the amount of activity recommended by the national standards. The standards recommend that children be active at least 50% of their time during the physical education (U.S. Department of Health and Human Services, 2008).
Other studies focused on recess school time. Pan (2008a) compared the percentage of time that children with and without autism spent in moderate-to-vigorous physical activity (MVPA) during the school recess. Forty eight children between 7 to 12 years of age participated. Children had to wear a uniaxial accelerometer during the 5 school days. The results reinforced that the children on the autism spectrum are less active even during school recess.

Not all research has shown children on the spectrum to be less active. Sandt and Frey (2005) published contrary findings. The purpose of their study was to compare the level of physical activity in children on the autism spectrum during daily physical education, recess and after school periods. They studied 15 children on the spectrum (divided into groups of ASD, Asperger’s and PDD-NOS) and 13 typically-developing controls. The age range varied from 5 to 12 years. The children were observed and also wore a uniaxial accelerometer device for 5 non-consecutive days,. There were no differences between children with ASD and the control for any activity periods. The Sandt and Frey findings are not typical of research in this area and may be due to the high group variability and the small number of participants.

In conclusion, there is an imperative need for research regarding to the amount of physical activity in children on the autism spectrum. Children on the autism spectrum may fail to engage on physical activity due to the nature of their disorder, in other words, the poor social interaction and also behavioral deficit may be constraints to the physical activity practice.

Motor proficiency achievement and its assessment tools.

A large number of research studies have been done using a wide variety of assessment instruments aiming to test motor function in different samples. There is no agreement on which assessment instrument is the most appropriate to determine motor dysfunction in children,
especially regarding this specific and heterogeneous population. Researchers have used the Bruininks-Oseretsky (BOT) assessment in two studies with the objective of differentiating motor impairments among Asperger’s syndrome (AS), autistic disorder and pervasive developmental disorder not otherwise specifies (PDDNOS). It was found that motor coordination was a common deficit in all three populations, but the AS group was less impaired than the other two groups. It has been suggested that more systematic studies with larger numbers of subjects are needed to help establish the motor/coordination deficits in children with ASD and PDD-NOS (Ghaziuddin & Butler, 1998; Ghaziuddin, et al., 1994). Similarly, Dewey et al. (2007) also used the BOT but in its short form to compare children with ASD to children with developmental coordination disorder (DCD) and attention deficit- hyperactivity disorder (ADHD). It was determined that all the groups had motor incoordination deficits, except the ADHD group. Berkley, Zittel, Pitney and Nichols (2001) examined the locomotor and object control skills in children with autism using the TGMD as assessment instrument. They reported that 73% of those children had gross motor skill delays. Page & Bouchert (1998) found “high rates of motor impairment” in children with autism using an informal observation of those children while running, jumping, hoping, and in examining their posture and gait.

Levels of gross (GM) and fine motor (FM) development in children with ASD was assessed by Provost, et al. (2007) using the Peabody Developmental Motor scales, 2nd edition (PDMS-2). They compared the skill levels of children with ASD to those with developmental disorder (DD) without ASD and concluded that there was a similar level of gross and fine motor skills between the groups. Reinforcing Provost et al., Dyck et al (2007) also assessed gross and fine motor skills but used a different instrument: the McCarron Assessment of Neuromuscular development. They verified a strong correlation between praxis and the deficit on social,
communicative, and behavioral skills, suggesting that dyspraxia may play an important role on this disorder. Green et al. (2009) tested the degree of impairment in movement skills in children with ASD using the Movement Assessment Battery for Children (M-ABC). They suggested that the assessment of movement skills should be part of the diagnostic process, since 79% of the children with ASD showed evident movement impairment and another 10% had “borderline problems”. These results confirmed another study done by Green, et al. (2002), in which motor delays in children on the spectrum were clearly showed. Using the same assessment instrument, Miyahara, et al. (1997) also showed motor impairments in Japanese children with autism, especially regarding to manual dexterity. Manjiviona and Prior (1995) used the Test of Motor Impairment-Henderson revision, which is a precursor of M-ABC, to compare motor skills between ASD and children with Asperger’s disorder. Both groups showed motor impairment, with no significant differences between the two groups.

Wiart & Darrah (2001) reviewed four of the commonly used motor skills assessment instruments: The Bruininks-Oseretsky Test of Motor Proficiency (BOT), the Movement Associated Battery for Children (M-ABC), the Peabody Developmental Motor Scale (PDMS), and the Test of Gross Motor Development (TGMD). They reviewed aspects regarding the validity, reliability, purpose, theoretical framework and also administration considerations. Each assessment tool had pros and cons, therefore, the authors suggest careful comparison in selecting the most appropriate assessment. Accordingly to the authors, BOT is a largely used and well-known motor assessment”, but there are concerns over reliability, validity, and clinical utility.

The BOT and M-ABC have been largely used to assess motor coordination in children on the Autism spectrum. Indeed, BOT is well known by its usefulness in clinical settings. This assessment instrument has just been revised and improved. The Bruininks-Oseretsky Test of
Motors Proficiency, 2nd (BOT-2) has much larger standardization sample and includes a broad age range (4 to 21 years of age) than the original BOT. The functional relevance of the items was increased, as well as the coverage of fine and motor skills. The BOT-2 improved the functional relevance of the test content, by adding more relevant items and removing the less relevant ones. All the eight subtests make a balanced contribution for the final score. The BOT-2 will verify fine and gross motor aspects using the eight subtests, as follows: 1) Fine motor precision, 2) fine motor integration, 3) manual dexterity, 4) bilateral coordination, 5) balance, 6) running speed and agility, 7) upper-limb coordination and 8) strength.

The Movement ABC is becoming the industry standard for identifying developmental coordination disorder (Brown & Lalor, 2009; Henderson, Sugden, & Barnett, 2007). Using this assessment will allow us to compare our study groups to associated clinical groups and its administration lasts 45 minutes. Like the BOT-2, the M-ABC-2 is used to determine the extent of impairment in fine and gross motor skills. It includes eight items divided into three subtests as follows: 1) manual dexterity, 2) ball skills, and 3) static and dynamic balance. The tests are also divided according to three age groups; therefore children perform different activities depending on their age range. This assessment has been revised as well, resulting in the second edition, the M-ABC 2. Brown and Lalor (2009) recently published a literature review about this assessment instrument. According to Brown and Lalor, the M-ABC-2 was re-standardized using a more representative population and the age range was extended. Overall, the structural changes result in a test that is easier to carry, the scoring system is simpler and the performance tests are more engaging for the children. However, there is no agreement about the reliability and validity of the M-ABC-2 (Brown & Lalor, 2009; Henderson, et al., 2007).
Hence, BOT-2 and M-ABC-2 when applied together may become a powerful assessment tool as will provide a very rigorous and detailed assessment of motor proficiency.

*Physical activity and assessment tools*

The accelerometer is a small device that provides physical activity measures, such as activity counts, steps taken, energy expenditure levels and intensity of activity. Accelerometers associated with a physical activity diary recall have been largely used to quantify physical activity. In case of children, the parent report regarding the physical activity of their children is the most commonly used method. The physical activity diary recall can be structured in numerous ways. Usually it is a checklist that contains a list of physical activity and a time table where the individual can fill out what kind activity was being done during certain periods of the day. This diary may give information about intensity, duration and frequency of the physical activity performed per period of time.

Some studies have shown that parents’ reports can be trusted (Bodnarchuk & Eaton, 2004; Ireton & Glascoe, 1995). However, the combination of the activity device along with the diary report has been extensively used and reported in the literature because the combination helps assure the validity and repeatability of diary reports (Bouchard, et al., 1983; Bringolf-Isler, et al., 2009; Burdette, Whitaker, & Daniels, 2004; Kohl, Fulton, & Caspersen, 2000; O’Connor, et al., 2003; Philippaerts, et al., 2006; Sallis, et al., 1996; Telford, Salmon, Jolley, & Crawford, 2004; Wrotniak, et al., 2006). A study done by O’Connor et al. (2003) has shown a high correlation between activity indices from parent report diaries and activity monitor recordings particularly during periods after school. The finding may be because parents usually are more aware of their child’s activity after school and thus their reports were more accurate.
Numerous studies have been done to validate the use of accelerometers in children. The accelerometers were found to be an appropriate method to quantify physical activity in children, as well as measure the energy expenditure in indoor and outdoor settings (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006; Puyau, Adolph, Vohra, Zakeri, & Butte, 2004; Rowlands, Thomas, Eston, & Topping, 2004; Sun, Schmidt, & Teo-Koh, 2008). Some studies have validated the use of the accelerometer device used by children and compared the results with their energy expenditure (EE). They also compared different placement sites for the accelerometer stating that the device should be as close as possible of center of body mass, such as hip or the lower back (Puyau, Adolph, Vohra, & Butte, 2002; Trost, McIver, & Pate, 2005). Ott, Pate, Trost, Ward, & Saunders (2000) aimed to verify the validity and reliability of the uniaxial and triaxial accelerometers during simulated “free playing” activities in 28 children between 9 and 11 years of age. The findings support previous studies showing that the accelerometers are adequate to measure children’s free play. Although there is no definitive evidence about what type of accelerometer is more reliable (Trost, et al., 2005), the study results of Ott et al. (2000) showed that triaxial accelerometers show a higher correlation with the actual energy expenditure than the uniaxial device, probably because triaxial accelerometer devices can capture movement in three different axis as opposed to one axis on the uniaxial type.

Previous research done using the accelerometers in children with ASD did not report any problem regarding the acceptance of these children to wearing the device (Pan, 2008a, 2008b; Pan & Frey, 2006). In fact, Sandt and Frey (2005) stated that children on the autism spectrum can tolerate the accelerometer.
Concluding Comments

In summary, motor proficiency is not a recognized criterion included in the diagnosis of autism spectrum disorders (ASD). The literature, however, is replete with reports of large proportions of children on the spectrum showing sensory-motor dysfunction and motor delay (gross and fine motor). From the literature on developmental motor learning and the development of expertise, the opportunity to engage and practice motor skills is essential in the acquisition of motor competence. In this study we explore the hypothesis that children on the spectrum are not getting enough physical activity to provide the necessary practice to acquire age-typical motor competence, thus accounting for the presence of general motor clumsiness as demonstrated in both gross and fine motor delay.

The goal of this study was to quantify the amount of physical activity in children with ASD as distinguished from non-diagnosed siblings and children classified as neurotypical controls and correlate the findings with the motor proficiency for the three groups of children. This study does not establish cause and effect, but the outcome may provide one of the first quantifications of time on task in the practice of motor activity in the ASD population. Assuming support for the present hypothesis, subsequent studies will be designed to provide interventions in motor skill acquisition to establish the capacity of those on the spectrum to acquire skills when provided sufficient practice. Hence, it was hypothesized that: 1) children with ASD will have lower scores than their non-diagnosed sibling and compared to the neurotypical controls on the two measures of physical activity (diary checklist of physical activity and accelerometer recordings); 2) siblings of ASD children and neurotypical children will not be different on the two measures of physical activity (diary checklist of physical activity and accelerometer recordings); 3) general scores of children with ASD on the motor skills assessment (BOT-2) will
be lower than the non-diagnosed siblings and lower than neurotypical controls; 4) There will not be a difference in the general score on motor skills assessment (BOT-2) between siblings of children with ASD and neurotypical children and 5) the BOT-2 general score will be positively correlated ($p < 0.05$) to the two physical activity variables (diary checklist scores and accelerometer data).
Chapter 3: Methods

The assessments of motor proficiency (BOT-2 and M-ABC-2) and the quantification of the amount of physical activity (accelerometer, diary checklist and video evidence) contributed to an identification of motor aspects of children with ASD and how it could affect the activity of daily living. Hence, the dependent measures in this study were motor skills proficiency and amount of physical activity.

Experimental Design

This was a descriptive, quasi-experimental study of three groups. The groups’ physical activity and motor proficiency were quantified in detail to provide averages, variability and ranges for an ASD group in a way that has not been available. In addition, it was a quasi-experimental study in that the ASD group was compared to two other groups of children not diagnosed with ASD. The dependent variables were physical activity and motor proficiency and the independent variable was group (ASD, neurotypical sibling of a child on the autism spectrum and neurotypical children). Finally, the relationship between physical activity and motor proficiency was assessed by correlational analysis.

The qualitative analysis was done with the entire sample, taking into consideration the quality and patterns of physical activity in these children when compared to the norm. Three aspects regarding physical activity were studied: a) verification of the type of physical activity in which children engage during physical education classes (light, moderate or vigorous physical activity); b) the number of steps taken per day in comparison to published norms and c) the difference in the type of physical activity engaged during weekdays and weekends. Additional
qualitative information was also provided by observation and evaluation of video recordings of participants during bouts of daily activity.

Participants

Participants in this study included three groups of children between 5 and 10 years of age. The total number of subjects was 11 divided among three groups: children on the autism spectrum (n = 4), neurotypical siblings of the children with ASD (n = 2) and neurotypical children with no cases of ASD in the immediate family or immediate past generation (n= 5). The age mean per group was: 8.06 (± 2.36) for autistic group, 7.04 (± 2.30) for sibling group and 8.32 (± 2.16) for the neurotypical group. All the children in the autistic group had a diagnostic of ASD. Two children dropped from this study: the ASD child could not tolerate the accelerometer and the other child was his sibling. The parents thought to be the best interest of both children to stop their participation.

Potential participants were screened during a telephone conversation with a parent. The screening determined suitability for the study. For children on the autism spectrum, inclusion criteria were: a) diagnosis of autism (ASD) or Pervasive Developmental Disorder – Not Otherwise Specified (PDD-NOS); b) IQ of 70 or above, c) inclusion in general education classes for at least 50% of the school day. The school inclusion criterion was used to screen for the participant’s verbal skill and help ensure at least moderate compliance to instruction. The IQ higher than 70 was previously determined by the health care provider and it was confirmed by use of the K-BIT-2 (Kaufman & Kaufman, 2004). The requirement of a minimum IQ of 70 and diagnosis of ASD or PDD were intended to aid in creating a more homogeneous group and minimize the impact of significant cognitive impairment. A child was excluded from the study if he or she was on medication to treat aggressive behavior; had a diagnosed comorbid condition that negatively impacted physical
performance (e.g., neurological disorders associated with muscle control) or other comorbid condition such as tuberous sclerosis, hearing or visual problems, neurological, psychiatric or genetic problems (e.g., epilepsy, Tourette, ADHD, or fragile X disorder). A screening checklist for comorbidities (Appendix A) was completed by the parents prior the assessments.

**Instruments**

To verify IQ scores reported by the health care provider, the Kaufman Brief Intelligence Test second edition (K-BIT-2) was utilized. Accordingly to the authors, this assessment is appropriate for screening high risk individuals who may require more detailed evaluation or who were previously assessed with a comprehensive evaluation (Kaufman & Kaufman, 2004). It provides verbal, non-verbal and IQ composite scores, distributed in three subtests: a) verbal knowledge; b) matrices and c) riddles. The assessment is directed for people from ages 4 to 90 years. The administration of the test requires 15 – 30 min. The answers are scored 1 or 0 for correct and incorrect answers, respectively. The assessment outcome yields raw scores to be converted to standard scores, percentile ranks and normal curve equivalents and the results are given as age-based standard scores (Homack & Reynolds, 2007).

The IQ composite reliability mean is 0.93 and the test-retest correlation coefficient is reported as 0.93 (Kaufman & Kaufman, 2004). The reliability mean for the vocabulary subtest is 0.93 and the test-retest correlation coefficient is, on average, 0.88. The matrices subtest has a reliability mean of 0.88 and test-retest correlation coefficient mean of 0.90 (Kaufman & Kaufman, 2004). The reliability was also reported by Homack and Reynolds (2007) where the reliability mean for IQ composite, verbal and non-verbal sub scores was 0.93, 0.90 and 0.88 respectively. In the report, the test-retest mean for the three subtests were 0.90 for IQ composite,
0.91 for verbal subtest and 0.90 for the non-verbal subtest. The K-BIT-2 construct and external validity is well defined with respect to the original the K-BIT and other IQ assessments (Homack & Reynolds, 2007; Kaufman & Kaufman, 2004).

Motor proficiency was verified using two well known motor assessments: Bruininks-Oseretksy motor proficiency test – 2nd edition (BOT-2) and Movement Assessment Battery for Children – 2nd edition (M-ABC-2). The BOT-2 was used to quantify fine and gross motor skills such as fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper-limb coordination and strength. The general composite score provides the standard scores, percentile rank, confidence intervals and a descriptive category (well below average, below average, average, above average, well above average). The BOT-2 scores may be converted to age-equivalence scores (Bruininks & Bruininks, 2005a). These age equivalents are norm-referenced scores that indicate the age at which the child’s point score is the average score. The BOT-2 is known for high validity and reliability. The reliability coefficients for the total composite are described as mid to upper 0.80 (Bruininks & Bruininks, 2005a, 2005b). Wuang & Su (2009) reported the test-retest reliability (ICC) and internal consistency for the BOT-2 total scale as excellent ($\alpha = 0.92$ and ICC = 0.99).

The Movement ABC 2nd Ed. (M-ABC-2) was used as well to verify fine and gross motor skills. It includes eight items divided into three subtests: 1) manual dexterity, 2) ball skills, and 3) static and dynamic balance. The 8 items of the M-ABC are different for each age band but cover similar skills. The three age bands are: 1) age band 1 – 3 - 6 years; 2) age band 2 – 7 - 10 years; 3) 11 - 16 years. The assessment activities differed depending on the age range. Age bands 1 and 2 were relevant in this study as participants ranged in age from 5 – 10 years of age.
M-ABC scores range from 0 to 5, with 5 indicating the highest level of impairment. Scores of 0 are achieved by 75% of the normative sample, and scores of 5 by the lowest 2%. A total impairment score is obtained from the sum of subsections and may then be converted to a centile rank. A raw score of 0 to 9.5 is considered to be within the average range, a score of 10 to 13.5 (5th–15th centile) is considered borderline, and scores of more than 13.5 (<5th centile) are indicative of definite motor difficulties. Centile cut-offs (15% and 5%) for the three subtests are also reported. Therefore, the raw performance score of each item is converted into a scaled score ranging from zero to five, with lower scores indicating a better performance. A range of percentile scores is matched to these scaled scores. The total impairment score of the test is the sum of the scaled scores, with a maximum of 40 (8 items x 5 points). The manual provides a table for converting the total impairment score into a percentile score.

**Equipment**

The ActiGraph activity monitor (model GT3X) (Figure 1) was used to quantify the amount of physical activity performed by the wearer. The ActiGraph collects motion data on three axes and consistently measures/records time varying accelerations from approximately 0.05 to 2.5 G’s. The accelerometer output is digitized at a rate of thirty times per second (30 Hertz). Once digitized, the signal passes through a digital filter that limits the accelerometer to the frequency range of 0.25 to 2.5 Hz. The GT3X is small and lightweight device (27 grams and dimensions of 3.8cm x 3.7cm x 1.8cm). This accelerometer can provide physical activity measure such as steps taken, energy expenditure and activity levels. Accelerometer devices are commonly used to quantify physical activity and have proven to be very reliable (Bringolf-Isler, et al., 2009; Puyau, et al., 2002; Tryon & Williams, 1996; Wrotniak, et al., 2006). The validation
and calibration of different types of accelerometers and their utilization in children also has been studied. Although the GT3X was not tested due to its recent availability, precursor models of the Actigraph GT3X were tested and their validity while testing children was confirmed (Freedson, Pober, & Janz, 2005; Puyau, et al., 2002; Trost, et al., 1998). Furthermore, triaxial accelerometers might be more valid than the uniaxial models due to the “torsional, non-vertical movement” typical of children’s activities (Ott, et al., 2000; Rowlands, 2007).

In this study, data were collected using a sampling interval of 60 s epochs, following the practice of similar studies done previously using accelerometers in children on the autism spectrum (Pan, 2007, 2008a, 2008b, 2009; Sandt & Frey, 2005). The activity count cut-off that corresponds to MET levels was based on Freedson, et al. (2005) and were pre-established by the actigraph GT3X, as showed in Table 1. In addition, the children wore the same accelerometer during 7 days to help ensure reliability of the data (Rowlands, 2007). In his work, Rowlands concluded that wearing the accelerometer for 7 days provides a reliable estimate of physical

Figure 1. Actigraph GT3X and its placement in the child’s waistline.
activity in children and it also allows the capture of weekdays and weekends, which is very important due to the differences in the activities during these days (Rowlands, 2007).

As verified by many authors, the accelerometer was placed dorso-lateraly on the waistline (Figure 1) (Puyau, et al., 2002; Trost, et al., 2005; Yngve, Nilsson, Sjostrom, & Ekelund, 2003). However, due to the nature of this study and the population being tested, the accelerometers were pinned at the children’s pants, instead of having them to wear the device on a belt or clip as is usually done. Children on the autism spectrum can be quite sensitive to any extra sensory stimuli, including the wearing of a belt, the texture of a new object. An alternative to wearing a belt was to use pins to fix the accelerometer to the child pants. This method of placement was adopted as a way of making the device less noticeable to the child, thus minimizing early drop-out from the study if the children became too distracted by the Actigraph.

The ActiGraph was set to start collecting data one day after the child’s initial assessment and was programmed to stop collecting after 10 days. This procedure helped to ensure that the equipment would be ready to collect data if the participant, for any reason, had to delay the start of wearing the device. The 10 day window allowed for the addition of days to the standard 7-day protocol. The procedure to place the accelerometer at the children’s pants was explained and demonstrated to the parents. The parent was instructed to place the accelerometer at the children’s pants either before or after the children had the pants on. Importantly, they were instructed to place the device at the same place in the children’s pants in all of the 7 days. The examiner oriented the parents to place the accelerometer at the same waistline side every day, just taking it off in case of bathing, swimming lessons or aquatic sports, or any contact sport that could harm the child and also at bedtime. The parents were encouraged to place the accelerometer on the children’s pants for 7 consecutive days. If, however, for any reason the
ActiGraph was not worn in any particular day, the parent was instructed to add one day to the end of the period. The same rule was applied to the diary checklist.

Table 1.

<table>
<thead>
<tr>
<th>Activity Intensity</th>
<th>MET Range</th>
<th>Activity Counts (cnts.min(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>&lt;3.00</td>
<td>&lt;1952</td>
</tr>
<tr>
<td>Moderate</td>
<td>3.00-5.99</td>
<td>1952-5724</td>
</tr>
<tr>
<td>Hard</td>
<td>6.00-8.99</td>
<td>5725-9498</td>
</tr>
<tr>
<td>Very Hard</td>
<td>&gt;8.99</td>
<td>&gt;9498</td>
</tr>
</tbody>
</table>

Freedson, et al. (2005)

The diary checklist reported by the parents provided the amount of physical activity (intensity, duration and frequency) (Appendix B). The diary checklist had 3 levels of activity intensity (light, moderate and vigorous) and was divided in 15 min intervals from 6:00 to 23:00 hs and from 23:00 until 6:00 the intervals increase to 1 hour each. The metabolic equivalent (METs) was used to determine the intensity of each activity as follows: a) Light intensity: <3 METs; b) Moderate: 3 – 6 METs and c) Vigorous exercise intensity > 6 METs. The same adapted diary checklist was used in Bringolf-Isler et al. (2009) in which they quantified the intensity and duration of physical activity and verified the “activity type/mode” in children between 6 to 14 years of age. The diary checklist data were used to substitute the accelerometer missing data due to organized and reported activities where this device could not be worn, for example, during swimming lessons. The diary checklist also added important information used in the qualitative analysis, such as frequency and time spent during physical education. The parents were instructed to answer the diary checklist as accurately as they could, including the school
period. They could either get the school schedule with the child’s teacher or ask the child about his/her schedule in order to fill the checklist regarding to the school period.

The six hours video recording (divided in two hours in two weekdays and two hours in one weekend day) was done using a digital video recording camera (flip video – ultra). The camera has a 4GB built in memory which allows up to 120 min of video recording with a resolution of 640 X 480 at 30 fps. The children were recorded in their home during a typical day while following their normal schedule. A video recording guideline (Appendix C) was given to the examiner, who was instructed to not interact with the child to avoid creating major changes in his/her behavior and activities. The information gathered by the videos collaborated in the qualitative analysis of the children’s physical activity later on.

**Procedures**

The present study protocol was approved by the university review board for protection of human subjects (Appendix D). The participants were recruited from Austin and surroundings communities through flyers (Appendix E) posted at doctors’ offices, clinics, schools and YMCA. Recruitment letter (Appendix F) was emailed to members of University of Texas Autism Project (UTAP) and autism group listservs. The consent form (Appendix G) was introduced to the parents/guardians of participants in one of three ways – by mail, via the web, or upon the first visit to the laboratory. Parents of potential participants were given the opportunity to read the consent form and ask questions. Subsequently, the parents were asked to sign the consent form. The study was explained to all children and they were given the opportunity to look at the equipment and ask questions. Children 7 years of age and older were asked to sign an assent
form. Children under the age of 7 years gave verbal assent. All participants, as well as their parents, were assured that they could terminate participation at any time.

The data were collected over eight days, as follow:

a) Day 2 - The experiment was explained to the parents/caregiver and to the child and a detailed the explanation and demonstration of the accelerometer placement was provided. The consent form was signed, followed by the measurements of weight and height. The IQ score was verified using the K-BIT-2 assessment, which had the required 15 – 30 min to assess. In addition to the IQ test, the children’s motor skills were assessed using BOT-2 and M-ABC-2. They performed fine and gross motor tasks pre-established in the two assessments, which included activities such as: drawing lines, copying shapes, sorting cards, jumping jacks, standing on one leg, hops, catching and throwing ball, push-ups and sit-ups, bouncing and catching a ball with one hand, placing pegs in a peg board, threading nuts on a bolt and so on. Approximately 90 minutes were required to complete both assessments on one child.

b) Days 2 to 8 – Children wore an accelerometer device (Actigraph) and their parent/caregiver completed the diary checklist for the waking hours. The device was placed at the waist line (pinned on the children’s pants) (Figure 1). The Actigraph was placed as soon as the children were awakened in the morning and it was removed just before bedtime at night. The same schedule was followed with the diary checklist. The parent began taking notes as soon as their children
woke up, continuing until bedtime. The children did everything that they would normally do during their day (i.e. go to school, practice sports, etc). The accelerometer data was not worn during sleeping time or during activities, such as showering and swimming. A guideline containing reminders about how, when and where wear and not to wear the accelerometer was provided to remind the parents about how to handle the device (Appendix H).

During the following week, the parents selected two weekdays and one weekend day during which video recordings of the child’s physical activity were made. The videos were recorded for 2 hours after school and recording typically active window of time on a weekend day. The video recordings were not taken during time covered by the diary checklist, thus the video records were not used as corroboration of parent reports. Instead, the video records were informally compared with parent-reported diary checklists to add qualitative information about children’s activity. In summary, on the first day, height and weight were measured followed by the K-BIT-2 IQ assessment. After that, gross and fine motor skills were assessed using the BOT-2 and M-ABC-2. The motor skills assessments were used to establish age equivalence for each of the eight subtests.

In summary, when all the tests were finished on Day 1, the examiner used safety pins to place the accelerometer on the children’s pants (waistline). The child wore the accelerometer for the rest of the day, using this time as a familiarization period. The next morning, the 7-day period for collecting accelerometer data began. The data collection from the familiarization period was not used in this study. During the week that the child wore the accelerometer, the parents completed the physical activity diary checklist.
In the following week, the child was video-recorded for 2 consecutive hours on three separate occasions. The video provided qualitative information about the children’s physical activity in addition to the quantitative information provided by the accelerometer and diary checklist.
Chapter 4: Results

This study was designed to test five hypotheses. The first hypothesis was that children with ASD would have lower scores than their non-diagnosed siblings and lower than the neurotypical control group on the measure of physical activity – accelerometer recordings. Secondly, we tested the hypothesis that ASD siblings and neurotypical children would not be different on the measure of physical activity. Not only did we expect children with ASD to engage in less activity, our third hypothesis was that motor proficiency scores for children with ASD would be significantly lower compared to the ASDsib and NT groups. The fourth hypothesis was that ASD siblings and children in the neurotypical control group would not differ on measures of motor proficiency. The fifth and final hypothesis was that the BOT-2 and MABC-2 general scores would be positively correlated (p < 0.05) with the two physical activity variables. What follows is a report of the findings.

Quantitative analysis

Non parametric statistical tests were chosen in this study due to the small sample size, uneven group sizes and large number of variables. The descriptive statistical analysis was used to determine the mean and standard deviation for percentage of time spent on moderate to vigorous physical activity (MVPA) for each of the three groups (Table 2) and motor proficiency (BOT-2 and M-ABC-2 standard scores) (Table 3). The Kruskal-Wallis test was used to determine the differences among the three group means and Spearman’s Rho correlation coefficient was used to measure the strength of linear dependence between the percentage of time spent on moderate to vigorous physical activity and motor proficiency scores (BOT-2 and M-ABC-2 scores) for all
three groups (ASD, ASD siblings and NT). In addition, an ANCOVA was used to test the effect of the covariate (BMI) on the two variables: percentage of time spent in MVPA and motor proficiency scores (BOT-2 and M-ABC-2 scores). However, it was verified that this covariate had no influence on the variables of physical activity and motor proficiency and therefore it was not taken into consideration in subsequent analyses and interpretations.

Table 2

Descriptive Analysis (Mean and SD) of Percentage of Time Spent Engaged in Physical Activity for the Three Groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Variables (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASD (n=4)</td>
</tr>
<tr>
<td>MVPA*</td>
<td>9% ± 4</td>
</tr>
<tr>
<td>MPA*</td>
<td>8% ± 4</td>
</tr>
<tr>
<td>VPA*</td>
<td>1% ± 0</td>
</tr>
<tr>
<td>Steps**</td>
<td>10193 ± 2240</td>
</tr>
</tbody>
</table>

* Percentage of time spent engaged in moderate and/or vigorous physical activity.
** Number of steps/day.

Table 3

Descriptive Analysis (Mean and SD) of Motor Proficiency Tests’ Standard Scores (BOT-2 and MABC-2) for the Three Groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Variables (Mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASD^a (n=4)</td>
</tr>
<tr>
<td>BOT-2</td>
<td>41.5 ± 9.1</td>
</tr>
<tr>
<td>MABC-2</td>
<td>6.3 ± 3.4</td>
</tr>
</tbody>
</table>

^a: Children on the Autism Spectrum
^b: Non-diagnosed sibling of children on the autism spectrum
^c: Neurotypical children who served as a control group
Analyses revealed no differences among the groups on age or physical features of the group. There was no significant difference among groups regarding age \((p = 0.50)\) or BMI \((p = 0.49)\) (Table 4). IQ was used as an exclusion criterion, with 70 set as a minimum score required for participation. Group means and standard deviations for IQ are presented in Table 2.

Table 4

Descriptive Characteristics (mean +/- SD) of Participants in each of three groups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Variables (Mean ± SD)</th>
<th>ASD(^a) (n=4)</th>
<th>ASDsib(^b) (n=2)</th>
<th>NT(^c) (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>8.06 ± 2.4</td>
<td>7.0 ± 2.3</td>
<td>8.3 ± 2.2</td>
<td></td>
</tr>
<tr>
<td>BMI*</td>
<td>17.2 ± 3.1</td>
<td>15.9 ± 0.9</td>
<td>16.8 ± 0.5</td>
<td></td>
</tr>
<tr>
<td>IQ**</td>
<td>91.8 ± 14.9</td>
<td>117.5 ± 13.4</td>
<td>124.8 ± 12.9</td>
<td></td>
</tr>
</tbody>
</table>

\(a: \) Children on the Autism Spectrum  
\(b: \) Non-diagnosed sibling of children on the Autism Spectrum  
\(c: \) Neurotypical children who served as a control group  

*BMI: Body Mass Index  
**IQ: Intelligence Quotient

It was hypothesized that children with ASD would have lower scores in both motor proficiency tests (BOT-2 and MABC-2) than the non-diagnosed siblings and the neurotypical children. It was also hypothesized that non-diagnosed siblings and neurotypical children would not differ in the motor proficiency tests’ scores. The Kruskal Wallis test did show a significant difference among groups regarding to the measure of motor proficiency BOT-2 \((p = 0.04)\), however no significance was found on MABC-2 scores \((p = 0.07)\) (Figure 2).
Regarding to the amount of physical activity, it was previously hypothesized that children with ASD would be less physically active than the non-diagnosed siblings and the neurotypical children. In addition, the hypotheses also stated that non-diagnosed siblings and neurotypical children would not differ on the amount time spent in PA. The Kruskal Wallis test showed no significant difference among the groups regarding the percentage of time spent engaged in moderate – to – vigorous physical activity (MVPA; \( p = 0.76 \)).
**Figure 3**: Differences in % Time spent Engaged in Physical Activity.

The following table presents a detailed summary of the Kruskal Wallis Test for the variables age, BOT-2, MABC-2 and percentage of time spent in MVPA (Table 5).

### Table 5

**Kruskal Wallis test of the means**

<table>
<thead>
<tr>
<th>Variables (Mean)</th>
<th>Age</th>
<th>BOT-2</th>
<th>MABC-2</th>
<th>MVPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>0.5</td>
<td>6.23</td>
<td>5.24</td>
<td>0.54</td>
</tr>
<tr>
<td>df</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.77</td>
<td>0.04</td>
<td>0.07</td>
<td>0.76</td>
</tr>
</tbody>
</table>
It was also hypothesized that the motor proficiency assessments and the amount of physical activity would be positively correlated. The two motor assessments (BOT-2 and MABC-2) were positively and significantly correlated ($r^2 = 0.68$ and $p = 0.20$; Figure 4). However, no statistically significant correlation was found between MVPA and either the BOT-2 or the MABC-2 (Table 6).

![Figure 4. Spearman’s rho correlation between BOT-2 and MABC-2.](image)

<table>
<thead>
<tr>
<th></th>
<th>MVPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>$r^2$</td>
<td></td>
</tr>
<tr>
<td>$p$</td>
<td></td>
</tr>
<tr>
<td>BOT-2</td>
<td>0.47</td>
</tr>
<tr>
<td>MABC-2</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Although the correlation between BOT-2 and MVPA was not statistically significant, it shows a positive trend line towards the expected correlation. This tendency can be seen in data presented in Figure 5.

Figure 5. Spearman’s rho correlation between BOT-2 and MVPA.
Qualitative analysis

The qualitative analysis was made based on standards for children in each of the variables, as follow: step count per day; physical activity during weekend versus weekdays; physical activity levels during physical education (PE) and discrimination between moderate and vigorous physical activity.

The mean step count did not differ among the three groups (Figure 6). It was also the case that none of the groups achieved more than 10,000 steps in average per day. The recommendation from US Department of Health and Human Services is that children should have more than 11,000 and 13,000 steps per day for girls and boys, respectively. Although it is not known the level of physical activity when the steps were taken (i.e. walking and running for 10 minutes will result in different levels of physical activity but the number of steps taken would be the same), it is clear in this study that children in general are spending less time participating in physical activity than is recommended.
Figure 6: Differences in steps mean among groups.

Previous authors have reported that children exhibited higher levels of MVPA on weekends (Trost, Pate, Freedson, Sallis, & Taylor, 2000). The present study show that the level of physical activity did not differ from weekdays and weekends (Figure 7).
An interesting finding emerged regarding the level of physical activity during physical education classes. The US Department of Health and Human Services recommends that 50% of time during PE classes should be spent in MVPA. Even though there was not a significant difference in percentage of time spent in MVPA during PE classes among the three groups ($p = 0.52$), children in this research spent the major part of their PE hours in light physical activity, engaging in MVPA only 16% of their time in PE (Figure 8).
A detailed analysis of the children’s physical activity level showed that they spent the major part of the MVPA in MPA in detriment of VPA (Figure 9). However, differences between the groups were not found for MPA or VPA ($p = 0.85$ and $p = 0.59$, respectively).

**Figure 8. Physical activity intensity during PE classes**
In addition, inferences from the video recording data showed that the parent/caretaker usually sets the time for physical activity and in order for children to engage in vigorous physical activity (VPA), they have to engage in organized physical activity (e.g., swimming lessons, karate). It was also observed that during the time spent in light physical activity, children from this sample spent most of the time playing video games or on the computer. In conclusion, organized PA is still the major source of exercise for children, especially for children on the autism spectrum (National Association for Sport and Physical Education, 2004; U.S. Department of Health and Human Services, 2008).

The Table 7 describes the summary of mean differences based on Kruskal Wallis test for the variables steps count mean per day, percentage of time spent in MVPA during physical
education classes (PE), differences in MVPA between weekdays and weekends and the difference between MVP and VPA within the MVPA data.

Table 7

*Kruskal Wallis test of the means*

<table>
<thead>
<tr>
<th>Variables (Mean)</th>
<th>Steps</th>
<th>PE*</th>
<th>Weekdays</th>
<th>Weekends</th>
<th>MPA</th>
<th>VPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chi-Square</td>
<td>0.72</td>
<td>1.30</td>
<td>0.30</td>
<td>1.51</td>
<td>0.32</td>
<td>1.05</td>
</tr>
<tr>
<td>df</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Asymp. Sig.</td>
<td>0.69</td>
<td>0.52</td>
<td>0.86</td>
<td>0.47</td>
<td>0.85</td>
<td>0.59</td>
</tr>
</tbody>
</table>
Chapter 5: Discussion

The abnormal social characteristics present in children with ASD result in a restricted repertoire of activity and interests that also may affect the motor learning process, creating fewer opportunities to practice motor skills and leading to a delay in achieving motor proficiency. Therefore, the practice of motor skills in the fundamental period of motor development is crucial, since these skills are the building blocks to acquire more specific and complex motor skills later on and consequently to achieve proficiency. Physical activity and motor proficiency are positively related and this correlation is well known. The practice of new motor skills is responsible for a smooth and well coordinated movement; therefore the amount of time spent in a physical activity is directly related to the level of expertise in neurotypical children. Hence, the specific aim of this study was to quantify the amount of physical activity in children with ASD and compare this value to non-diagnosed siblings (ASD siblings) and neurotypical controls (NT), as well as to compare the amount of physical activity between neurotypical controls and ASD siblings. The amount of physical activity is defined, in this study, by the percentage of time spent in moderate-to-vigorous physical activity (MVPA).

Delimitations should be considered in this study. Inferences from this study can be made only to children of both genders with ASD, siblings of children with ASD and NT within the age range of 5 to 10 years. The study is also delimited to children whose IQ is greater than 70.

There are some limitations to this study. A large sample could make the results statistically significant more reliable. Also, including more days in the data collection and spreading them throughout the year could be more representative. Another possible limitation is the lack of standardization of the diary checklist, even though the questionnaire provides a list of activities and the amount of time that the children spent during each activity and the intensity is
based on METs for each of the activity. However, these METs were pre-established in a compendium of physical activity that coded each activity based on the energy expenditure (EE) and provide the best possible estimation of activity through self-report other type of reports. In addition, the diary checklist will be based on a parental report and because of that will rely on parents/teacher recall of activities during some hours of the day (i.e. school hours) which could reflect under or over estimate of children’s physical activity.

Another limit is that the accelerometer cannot be worn during activities in the water (i.e. shower, swimming pools). Therefore these activities will not be recorded in the accelerometer device and will result in an underestimation of their amount of physical activity. Children with ASD can also be overwhelmed by wearing the accelerometer device (sensitivity to external stimulus) and even by being tested in a laboratory. Even more, these ASD children could be easily frustrated especially because they have difficulty maintaining attention on projects. These two factors might also serve to limitations in this study because these children could change their behavior. They could, for example, be more agitated, and the accelerometer might record physical activity that is atypical, biasing the results. Also, some parents might stop their participation in the study if their children start becoming overwhelmed. Reports from parents regarding these types of limitations will be discussed at the time, with a decision being made whether to replace these children in the study with a substitute. Replacements would be reported and analyzed at the conclusion of this study.
The quantitative analysis

The quantitative analysis was done on the four following variables: a) motor proficiency – BOT-2 scores; b) motor proficiency – MABC-2; c) amount of physical activity – percentage of time spent in MVPA and d) correlation between motor proficiency standard scores (BOT-2 and MABC-2) and amount of physical activity (MVPA). The results showed a statistically significant difference among groups regarding to the BOT-2 mean standard scores. However, the difference in the MABC-2 mean standard scores among groups was not statistically significant. However there was a positive correlation between the two motor assessments (p < 0.05). This discrepancy on the motor assessments significances could be explained by the structure of each of the assessments. The BOT-2 provides five descriptive categories to describe the levels of motor proficiency (well above average; above average; average; below average and well below average), as opposed to three descriptive categories provided by MABC-2 (green zone, amber zone and red zone). Regardless of the statistical significance, there were clear differences in motor proficiency among the three groups for both motor assessments and these differences are truly relevant for the clinical settings. Green at al. (2008) stated that motor impairment is very common in children with ASD and suggested that motor assessments should be part of a clinical routine. This would assure early and an appropriate intervention (Reiersen, Constantino, & Todd, 2008).

The differences regarding motor proficiency scores, especially between the ASD group and the two NT groups (ASDsisb and NT) shows a clear trend line in support of the hypotheses: the ASD group showed greater impairment compared to the other two groups on both motor assessment tests. The clinical significance of this finding has already been demonstrated in other studies where the difference between the ASD group and a control group was evident and
The present study did not present the same results as previous studies more likely due to the small sample size and high variability in the three groups tested.

The amount of physical activity was reported using the percentage of time spent during MVPA rather than minutes, to accommodate inconsistencies in time across the sample. The difference in the amount of physical activity among the three groups was found not to be statistically significant. Previous research has shown that children with autism significantly less active than their neurotypical peers. A study done by Pan (2008a) was the only one that intended to quantify the percentage of time that children with ASD and NT spend in MVPA. However, this study focused on recess time at schools for 5 days. The results showed that even though all children were less active than the recommended by USDHHS, the children with ASD were significantly less active than the NT control. This research intended to replicate and extend Pan’s study. In the present research we extended number of variables, added a group of siblings of children on the spectrum. Given the number of participants in the current study, there is insufficient power to detect any significant difference in the amount of physical activity among groups. There is a need for a large sample size. Thus present findings could be explained by the small sample size. In addition, the accelerometer cannot be worn during activities in the water (i.e. shower, swimming pools). Therefore these activities will not be recorded with the accelerometer device. Replacement of these missing data was done using the information from the physical activity diary checklist. The diary checklist is based on a parental report and because of that the data are dependent upon a parent’s or teacher’s recall of activities during some hours.
of the day (i.e. school hours). Such recall may produce under or over estimate of children’s physical activity.

Regardless of the group to which they belonged, the children tested in this study were less active than the recommended by the National Association for Sport and Physical education (NASPE). Their recommendation states that children should spend 120 min of moderate-to-vigorous physical activity daily (at least 60 minutes of MVPA accordingly to USDHHS).

The correlation between motor proficiency and amount of physical activity proposed by this study was not found to be statistically significant. However, the correlation between the BOT-2 scores and the amount of physical activity (percentage of time spent in MVPA) showed once more a trend line towards the positive correlation between the two variables. The correlation between physical activity and the motor proficiency is well defined in NT children (Adolph, et al., 2003; Castelli & Valley, 2007; Ericsson, 2008; Ericsson & Charness, 1994; Fisher, et al., 2005; Haga, 2009; Okely, et al., 2001; H. G. Williams, et al., 2008; Wrotniak, et al., 2006). Wrotniak et al. (2006) findings showed a positive association between physical activity and motor proficiency and an inverse association between motor proficiency with sedentary activity. Recently, Wrotniak, Salvy, Lazarus, & Epstein (2009) explored the motor proficiency relationship among siblings. No relationship was found among siblings with respect to general motor proficiency, as they performed significantly differently on the motor assessment. The sibling’s relationship suggested by Wrotniak was confirmed by the present study, where the performances were different between siblings, in the motor proficiency measures (statistically significant for BOT-2) and physical activity (not statistically significant).
The qualitative analysis.

The qualitative part of this study was concern about step counts per day; level of physical activity during weekend versus weekdays, level of physical activity during PE classes and percentage of time spent in moderate PA and vigorous PA. Considerations about the environment as well as how children spent their free time were also commented.

The steps taken per day did not differ among the three groups. Moreover, none of the groups had more than 10,000 steps on average per day. The correlation between the step count and the amount of PA (percentage of time spent in MVPA) was strong and positively correlated ($p = 0.013$ and $r = 0.71$). Note that the recommendation from US Department of Health and Human Services is that children should have more than 11,000 and 13,000 for girls and boys, respectively. Although it is not known the energy requirements of the physical activity when the steps were taken it is clear in this study that children in general are spending less time during physical activity than it is recommended. The finding that step count is positively correlated with percentage of time engaged in moderate to vigorous physical activity supports the general observation that children, regardless of group membership, are not spending enough time in physical activity. This finding concurs with the low amount of PA demonstrated by children in prior studies.

The amount of physical activity during weekdays and weekends did not differ, confirming previous studies (Pan & Frey, 2006; Sandt & Frey, 2005). Pan and Frey (2006) studied the physical activity patterns in thirty youths with ASD (age range 10 to 19 years) and found that in addition to the low amount of PA, the ASD participants did not displayed difference in level of PA between weekdays and weekends, however they showed more bouts of five to ten minutes of continuous MVPA during weekends, when compared to weekdays.
The present study also verified the intensity of physical activity during physical education (PE) classes. It was found that children were not spending PE class time at the intensity recommended by U.S. Department of Health and Human Services (2008) and National Association for Sport and Physical Education (2004). The recommendation is for children to spend at least fifty percent of time in PE class in engaged in moderate to vigorous physical activity. There was no statistically significant difference among groups regarding this measure, however the low percentage of time spent in MVPA during PE classes is extremely important because the PE classes could be a good source of physical activity and could also improve the daily amount of physical activity for children. These findings are consistent with previous research (Pan & Frey, 2006; Sandt & Frey, 2005).

Another approach regarding to the intensity of PA was attempted in this study. The MVPA was segregated in moderate physical activity (MPA) and vigorous physical activity (VPA) to verify the correlation between these two separate measures with motor proficiency and also to discriminate the percentage of time spent in each of the intensity levels. Consistent with previous research (H. G. Williams, et al., 2008), children in this research engaged most of their active time in moderate physical activity, not vigorous physical activity. This finding was not statistically significant, but the percentages of time support the general observation of insufficient intensity in children’s physical activity.

No significant outcome was observed when time in moderate physical activity or vigorous physical activity was correlated with motor proficiency. Even though this finding was not statistically significant, there are clearly clinically relevant implications because the inactivity and sedentary behavior can place these children in risk, especially regarding to health, such as obesity (U.S. Department of Health and Human Services, 2008).
Information from the video recordings was used in this research with the objective of providing more of a narrative about how children are spending their time. The video recording revealed that the diary checklist could be misfiled in some instances. For example, the fact that children were recorded as playing outdoors cannot be interpreted as engagement in moderate or vigorous physical activity. They could be playing quietly at the playground or sand box, for example.

From the quantitative part of this study it was verified that children in general spend the most part of their time in light physical activity (LPA). This was confirmed by the video recordings and it was possible to affirm that the predominant activity during the light physical activity period was playing video-games or computer. Even though all the houses had a backyard and most of them had a play-set area for children’s play, the children always preferred to stay inside with the video games. Because of that, it was often observed that the parent/caretaker usually had to set the time for the physical activity. These observations confirm the findings in previous studies where the importance of organized physical activity lies in increasing the amount of time spent in moderate to vigorous physical activity (National Association for Sport and Physical Education, 2004; H. G. Williams, et al., 2008).
Chapter 6: Conclusion

This is the first known attempt of quantifying the amount of physical activity in children with ASD with a comparison of the obtained results with their neurotypical siblings and a neurotypical control group. This study also presents the first attempt at correlating the amount of physical activity with motor proficiency in children on the autism spectrum. The validity of this study was enhanced by using: a) three measures to quantify physical activity (accelerometer, diary checklist of PA and video recording) b) a 7-day monitoring period and c) two measures to verify the motor proficiency (BOT-2 and MABC-2). The small sample size limited the findings in this research. The motor proficiency assessment (BOT-2) was significantly different among groups and BOT-2 and MABC-2 were strongly correlated. However, group differences on the MABC-2 did not reach significance.

Measures of the amount of physical activity were not statistically significant among groups, however the inactivity observed by these findings are certainly clinically relevant. The correlation between amount of physical activity and motor proficiency did not reach significance but the data did follow a trend line towards a positive correlation. This correlational analysis has already been successfully done in many other researches on neurotypical children, therefore the limitation due to the sample size plays a definite role in the results presented in this study. A large sample could make the results statistically significant thus more reliable. Also, including more days in the data collection and spreading them throughout the year would be more representative.

In summary, regardless of the statistical significance, the clinical importance of this study was to demonstrate once more that there are differences in the motor skills between children with
ASD and neurotypical children, even the sibling’s motor skills were much closer to the neurotypical children than the children with ASD. In addition, children in this research are clearly not achieving the amount of MVPA required to maintain a healthy life, regardless of the environment that they are in (schools or home). Therefore, the early detection of a possible motor impairment is really important because allows a proper intervention; moreover, it diminishes the impact of this impairment in the critical period of motor development.

**Significance of this study**

As far as we are aware, no systematic study has quantified the amount of physical activity in children with ASD during a typical week. Moreover, no study has registered the correlation between motor proficiency and physical activity in children with ASD and compared the findings with their neurotypical siblings. This information would help us verify which constraints have more impact on the motor behavior of children with autism: the biological or the environmental constraints. It is well documented that children with ASD tend to be more isolated and may avoid social interaction. However, an objective understanding of the degree to which children with ASD are being inactive is not known - neither the role nor the possible relationship between the lack of physical activity and motor proficiency. Therefore, the goal of this study is to quantify the amount of physical activity engaged in by children with ASD and to correlate this finding with the gross and fine motor delay typically shown by children on the autism spectrum. If it is confirmed that children with ASD participate in inordinately low levels of physical activity and that there is a strong correlation between low activity levels and motor delay, then this finding can provide a compelling rationale to test the effect of a strong behavioral intervention to decrease the motor delay in children with autism spectrum disorders. This
evidence would also allow the implementation of a stronger curriculum regarding physical activity at schools and autism programs, as well as make possible the establishment of a national physical activity program for those with autism spectrum disorders in general. Decreasing the motor delay will promote the social inclusion of these children and consequently lead to a better social interaction between the children and their neurotypical peers and family. As a result, the general learning process in children with ASD would be expected to improve as reflected in activities of daily living peer and family relationships, and performance at school.
Appendix A - Screening Checklist
**Screening Checklist for Medical Conditions**

Parent/caregiver name: ______________________________________________________________

Date of Screening:___________________

Child’s Diagnosis: ( ) Autism ( ) Autism Spectrum ( ) High functioning Autism ( ) PDD-NOS ( ) Asperger’s

Diagnosis received from:
( ) Pediatrician ( ) Neurologist ( ) Psychiatrist/Psychologist ( ) School-based personnel ( ) Other (describe __________________)

Does your child have any of the medical conditions (Zafeiriou, Ververi, & Vargiami, 2007) described below? Please, check or identify all that apply:

<table>
<thead>
<tr>
<th>Medical Condition</th>
<th>( ) YES</th>
<th>( ) NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Retardation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Epilepsy/Seizures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attention Deficit Hyperactivity Disorder (ADHD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mood abnormalities (anxiety, depression, OCD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Down Syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tourette Syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fragile X Syndrome</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuberous Sclerosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing or Visual deficits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenylketonuria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Encephalitis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stimuli sensitivity (light, touch, odors, other)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sleeping abnormalities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duchenne muscular dystrophy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypotonia/hypertonia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other muscular condition not listed *</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
*If YES, please explain:

---

60
Does your child take any kind of medication? If yes, please list below:  ( ) YES  ( ) NO
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Does your child participate in any kind of therapy (PT, OT, speech therapist, others)?  ( ) YES  ( ) NO
If yes, please, list below:
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________
____________________________________________________________________________________

Parent/caregiver signature: ______________________________________________________________

Signature of screener (date) ____________________________  ( _______________ )
Appendix B- Physical Activity Diary Checklist
List of activities: Nursery school/first year

| Activity                                                                 | 6:00 | 7:00 | 8:00 | 9:00 | 10:00 | 11:00 | 12:00 | 13:00 | 14:00 | 15:00 | 16:00 | 17:00 | 18:00 | 19:00 | 20:00 | 21:00 | 22:00 | 23:00 | 00:00 |
|--------------------------------------------------------------------------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Sleeping                                                                 |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Eating                                                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| School/nursery school:                                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Lessons/nursery school                                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Physical education                                                       |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Recess                                                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Leisure time:                                                            |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Homework                                                                 |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Reading or browsing through books on his/her own                         |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Playing a musical instrument or singing                                  |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Watching TV, videos or DVDs                                              |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Computer, video games, Playstation, Nintendo or internet                |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Other quiet activities or games (listening to music or stories, drawing, painting, handwork or board games) |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Relatively vigorous games with friends / siblings (playground, role-playing, hide-and-seek etc) |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Vigorous games, running around or ball games (not in a sports club)      |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Training, riding or ballet (in a club)                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Travel                                                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| By foot                                                                  |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| By bicycle, scooter, inline skates or skateboard                         |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| By train, tram or bus                                                    |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| By car                                                                   |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Special                                                                  |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Accelerometer removed (e.g. during swimming)                            |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |
| Activity difficult to classify *describe below                           |      |      |      |      |       |       |       |       |       |       |       |       |       |       |       |       |       |       |       |

Please indicate your child's activities today (to the nearest quarter of an hour)

PLEASE CHECK THE INFORMATION THAT YOU HAVE PROVIDED ABOVE TO ENSURE THAT THERE ARE NO GAPS.
Appendix C - Guidelines for Video Recording
Guidelines for Physical Activity Video-Recording.

Task: Video record daily activities of children at home. You will be observing and video recording the typical activities of a child during at home activity for a 2 hour period.

There are some tips and guidelines to follow:

1. Dress appropriately. Remember that you are a guest in someone else’s home. You are a representative of The University of Texas and the success of our project depends upon your professional behavior.
   b. Introduce yourself to the parent. Confirm that you are there as part of the research study being conducted by Ana Leandro in the Department of Kinesiology & Health Education.
   c. **Carry your student ID and show it to the parent when you arrive at the house.**
   d. Do not wear perfume or cologne – children (particularly children with autism) are very sensitive to smells. Be careful of eating garlic or spicy foods prior to arriving at the child’s home.
   e. If you smoke, do not smoke in the hour prior to arriving at the child’s home. Brush your teeth or use mouthwash/gum to reduce smoker’s breath.
   f. Be cautious of dangling earrings. Children are notorious for pulling on earrings and chains.
   g. Do not wear a hat in the home of the child. It is common courtesy to remove hats indoors.
   h. Be sure your shoes are clean when you enter the home. Ask the parent if they would like for you to remove your shoes.
   i. Take a water bottle. Do not ask for water, or even to use the restroom. Do not assume you can go anywhere in the client’s home. Always ask permission.
   j. Ask the parent or guardian if there are places you should NOT go while video taping the child. While the goal is to record 2 hours of the child’s activities, do not assume you can go anywhere in the house. Check with the parent first about areas that are off-limits.

2. Turn your cell phone off while you are at the child’s home. Your attention must be on the video recording task. Do not take or receive calls. Do not send or check text messages. The quality of our research data depends upon your attention to the video recording task.
3. Do not interact with the child. Remember that they need to do the activities that they normally do. Children are naturally curious and social. Introduce yourself to the child, tell the child your name, and explain that you are visiting for the day and want to see what he/she does when they play at home. If the child encourages you to play with him/her, politely say that you are just there to watch the games and activities the child plays, but that you cannot play.

4. If two children in the same home participated in the study, you will video record one child at a time. Your assignment during one visit is to video record one child.

5. Make note of the time you start and the time that the recording ends.

6. Tips for good video recording:

   a. Ensure good lighting. Avoid pointing the camera at windows when recording indoor video. Avoid shooting into the sun when recording outdoor video. The quality of our data depends upon the quality of the video.
   b. Make slow movements when following the child. The camera is very sensitive and fast moves are not pleasant to watch.
   c. Keep your distance. The purpose of video is to document the child’s activities. We need to see the whole body – not head shots.
   d. Do not interact with the child. Keeping your distance (e.g., recording video from across the room rather than standing next to the child) will encourage the child to play naturally, and not seek you out as a play partner.
   e. Use common sense – don’t follow a child into the bathroom just so you can record continuously for 2 hours. Don’t video record a child changing clothes. If a parent asks you to stop recording, then follow the parent’s instruction. You must determine if the parent wants you to stop momentarily, or if they want to stop for the day.

7. Respect the privacy of the family. You are assisting with a research study. This is an educational opportunity for you. Remember, however, that you are in a private home. When you talk to others about what you observed, do not use names, do not reveal the address of the study participant.

8. If the child you are videotaping spends time playing with another child who is not a member of the family, attempt to avoid including the other child in the video.

9. After completion of a video recording session, the camera and accessories must be returned to Ana Leandro within 24 hours of the video recording session. If you have any questions, contact: Ana Leandro- ana_leandro@mail.utexas.edu phone: 232-2686
Appendix D-IRB Approved Protocol and Synopsis
Dear Jody Jensen, Ana C Leandro, Rutvi T Shah,

In accordance with Federal Regulations for review of research protocols, the Institutional Review Board has reviewed the above referenced protocol and found that it met approval under an Expedited category for the following period of time: 02/05/2010 - 02/04/2011. (expires 12am [midnight] of this date.)

Expedited category of approval:

☐ (1) Clinical studies of drugs and medical devices only when condition (a) or (b) is met. (a) Research on drugs for which an investigational new drug application (21 CFR Part 312) is not required. (Note: Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review). (b) Research on medical devices for which (i) an investigational device exemption application (21 CFR Part 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

☐ (2) Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as follows: (a) from healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or (b) from other adults and children, considering the age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

☐ (3) Prospective collection of biological specimens for research purposes by Non-invasive means. Examples:

(a) hair and nail clippings in a non-disfiguring manner;
(b) deciduous teeth at time of exfoliation or if routine patient care indicates a need for extraction;
(c) permanent teeth if routine patient care indicates a need for extraction;
(d) excreta and external secretions (including sweat);
(e) uncannulated saliva collected either in an un-stimulated fashion or stimulated by chewing gumbase or wax or by applying a dilute citric solution to the tongue;
(f) placenta removed at delivery;
(g) amniotic fluid obtained at the time of rupture of the membrane prior to or during labor;
(h) supra- and subgingival dental plaque and calculus, provided the collection procedure is not more invasive than routine prophylactic scaling of the teeth and the process is accomplished in accordance with accepted prophylactic techniques;
(i) mucosal and skin cells collected by buccal scraping or swab, skin swab, or mouth washings;
(j) sputum collected after saline mist nebulization.

☐ (4) Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications). Examples:
(a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject’s privacy;
(b) weighing or testing sensory acuity;
(c) magnetic resonance imaging;
(d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography;
(e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing
where appropriate given the age, weight, and height of the individual.

☐ (5) Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis). (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(4). This listing refers only to research that is not exempt).

☐ (6) Collection of data from voice, video, digital, or image recordings made for research purposes.

☐ (7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies. (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b)(3). This listing refers only to research that is not exempt).

☐ Please use the attached approved informed consent

☐ You have been granted Waiver of Documentation of Consent
According to 45 CFR 46.117, an IRB may waive the requirement for the investigator to obtain a signed consent form for some or all subjects if it finds either:
☐ The research presents no more than minimal risk
AND
☐ The research involves procedures that do not require written consent when performed outside of a research setting
<OR>
☐ The principal risks are those associated with a breach of confidentiality concerning the subject’s participation in the research
AND
☐ The consent document is the only record linking the subject with the research
AND
☐ This study is not FDA regulated (45 CFR 46.117)
AND
☐ Each participant will be asked whether the participant wishes documentation linking the participant with the research, and the participants wishes will govern.

You have been granted Waiver of Informed Consent
According to 45 CFR 46.116(d), an IRB may waive or alter some or all of the requirements for informed consent if:
☐ The research presents no more than minimal risk to subjects;
☐ The waiver will not adversely affect the rights and welfare of subjects;
The research could not practically be carried out without the waiver; and
Whenever appropriate, the subjects will be provided with additional pertinent information they have participated in the study.
This study is not FDA regulated (45 CFR 46.117)

RESPONSIBILITIES OF PRINCIPAL INVESTIGATOR FOR ONGOING PROTOCOLS:

(1) Report immediately to the IRB any unanticipated problems.

(2) Proposed changes in approved research during the period for which IRB approval cannot be initiated without IRB review and approval, except when necessary to eliminate apparent immediate hazards to the participant. Changes in approved research initiated without IRB review and approval initiated to eliminate apparent immediate hazards to the participant must be promptly reported to the IRB, and reviewed under the unanticipated problems policy to determine whether the change was consistent with ensuring the participants continued welfare.

(3) Report any significant findings that become known in the course of the research that might affect the willingness of subjects to continue to take part.

(4) Insure that only persons formally approved by the IRB enroll subjects.

(5) Use only a currently approved consent form (remember approval periods are for 12 months or less).

(6) Protect the confidentiality of all persons and personally identifiable data, and train your staff and collaborators on policies and procedures for ensuring the privacy and confidentiality of participants and information.

(7) Submit for review and approval by the IRB all modifications to the protocol or consent form(s) prior to the implementation of the change.

(8) Submit a Continuing Review Report for continuing review by the IRB. Federal regulations require IRB review of on-going projects no less than once a year (a Continuing Review Report form and a reminder letter will be sent to you 2 months before your expiration date). Please note however, that if you do not receive a reminder from this office about your upcoming continuing review, it is the primary responsibility of the PI not to exceed the expiration date in collection of any information. Finally, it is the responsibility of the PI to submit the Continuing Review Report before the expiration period.

(9) Notify the IRB when the study has been completed and complete the Final Report Form.

(10) Please help us help you by including the above protocol number on all future correspondence relating to this protocol.

Sincerely,

[Signature]

James P. Wilson, Ph.D.
Professor
Vice Chair, Institutional Review Board
Synopsis of Research

I. Title: “How do Children Spend their Time? The Quantitative and Qualitative Analysis of Physical Activity in Children on the Autism Spectrum”

II. Investigators (co-investigators):

Jody L. Jensen, Ph.D (Principal Investigator), Dept. of Kinesiology and Health Education
Ana Leandro, BPT (Co-Investigator), Dept. of Kinesiology and Health Education
Rutvi Shah, BPT (Co-Investigator), Dept. of Kinesiology and Health Education

III. Hypothesis, Research Questions, or Goals of the Project

Physical competence is not a recognized criterion included in the diagnosis of autism spectrum disorders (ASD). The literature, however, is replete with reports of large proportions of children on the spectrum showing sensory-motor dysfunction and motor delay (gross and fine motor). From the literature on developmental motor learning and the development of expertise, the opportunity to engage and practice motor skills is essential in the acquisition of motor competence. In this study we explore the hypothesis that children on the spectrum are not getting enough physical activity to provide the necessary practice to acquire age-typical motor competence, thus accounting for the presence of general motor clumsiness as demonstrated in both gross and fine motor delay.

The goal of this study is to quantify the volume of physical activity in children with ASD as distinguished from non-diagnosed siblings and children classified as neurotypical controls. This study does not establish cause and effect, but the outcome will provide one of the first quantifications of time on task in the practice of motor activity in the ASD population. Assuming support for the present hypothesis, subsequent studies will be designed to provide interventions in motor skill acquisition to establish the capacity of those on the spectrum to acquire skills when provided sufficient practice.

IV. Background and Significance:

The autism spectrum is comprised of complex, mild-to-severe, pervasive neurodevelopment disorders characterized by a broad range of social abnormalities, language deficits and deficiencies in motor skills (American Psychiatric Association, 1994; Ming, et al., 2007). The majority of those on the spectrum present with significant motor dysfunction including delays in milestones, postural instabilities, poor balance, abnormal gait patterns, poor tool use, as well as deficits in imitation/mimicry, and poor motor coordination. Overall, there is an inability to initiate, switch, efficiently perform or continue ongoing action (Damasio & Maurer, 1978; Gowen, et al., 2008; Hamilton, 2008; Jones & Prior, 1985; Kohen-Raz, et al., 1992; Larson, et al., 2008; Manjiviona & Prior, 1995; Mari, et al., 2003; Teitelbaum, et al., 1998; Vilensky, et al., 1981).

In addition to deficits in motor skills, the social interaction and communication skills in children with ASD are substantively impaired (American Psychiatric Association, 1994; World Health Organization, 1992) accounting for the failure of those on the spectrum to develop appropriate peer relationships. The lack of innate intuition and verbal skill contributes to deficits in learning processes. The intuitive and non-verbal social skills are important skills in learning for the process of observation (mirroring others) as a mechanism for learning new social and motor skills (Lepage & Théoret, 2007) (J. H. G. Williams, et al., 2001). These abnormal social characteristics result in a restricted repertoire of activity and interests negatively impacting the motor learning process. The consequent social isolation
and limited (sometimes non-existent) interest in establishing social interactions creates fewer opportunities to practice motor skills leading to a delay in achieving motor proficiency.

The skills learned in early childhood are the building blocks for more specific and complex motor skills. The complex motor skills are honed through practice in search of proficiency. Wrotniak, Epstein, Dorn, Jones, & Kondilis (2006) showed a positive association between physical activity and motor proficiency, with corresponding data showing sedentary behaviors to be inversely related to motor proficiency.

Motor proficiency is the bedrock of functional independence. Motor competence is not a diagnostic criterion for autism spectrum disorders, but the lack of motor proficiency is a nearly universal finding in the diagnosis of ASD. It is because of the importance of early childhood motor proficiency to later functional independence that we undertake this study. Is the motor proficiency seen in ASD the result of lack of practice or a neuromotor consequence of the neurodevelopmental disability? The aim of this study is to assess the opportunities for practice. In this study we assess motor competency and determine the volume of physical activity engaged in by children on the autism spectrum and compare those findings to data from non-diagnosed siblings and children outside the family who serve as neurotypical controls. The first hypothesis is that children with ASD are significantly behind their age-matched peers and their siblings in motor skill competency. A second hypothesis is that children with ASD show a significant reduction in the volume of physical practice of gross motor skills.

V. Research Method, Design, and Proposed Statistical Analysis:

Participants in this study will include three groups of children between 3 and 10 years of age. The three groups will be children on the autism spectrum (n=20), neurotypical siblings of the children with ASD (n=20) and neurotypical children with no cases of ASD in the immediate family or immediate past generation (n=20), in a total of 60 children. An additional 10 children may be recruited to accommodate study mortality.

A descriptive statistical analysis will be used to determine the mean and standard deviation for age, BMI (body mass index), IQ, physical activity and motor proficiency for each of the 3 groups. The ANCOVA will be used to test the effect of covariates (BMI and IQ) on the amount of physical activity and motor proficiency scores (BOT-2 scores). The Pearson product-moment correlation coefficient will be used to measure of the strength of linear dependence between amount of physical activity and motor proficiency scores (BOT-2 scores) for all three groups (ASD, ASD siblings and NT).

VI. Human Subject Interactions

A. Identify the sources of potential participants:

The participants will be recruited from Austin and surroundings communities. Recruiting resources will include The University of Texas Autism Project (UTAP), Autism listservs (e.g., the Autism Society of Greater Austin Yahoo group, the Autism Society of Austin). Recruiting letters will be placed in the medical offices of Dr. Dilip Karnik (pediatric neurologist whose practice is largely composed of clients with autism spectrum disorders) and Dr. Kendal Stewart (otolaryngologist, whose client base includes upwards of 2000 individuals with autism spectrum disorders), and other pediatricians/physicians who’s practices include a component of autism spectrum disorders. A cover letter containing information about this research project will be picked up or distributed (email or postal mail) to all families associated with the recruiting groups. Those parents interested in the study will be asked to contact Ana Leandro, by email or phone.
Potential participants will be screened during telephone conversation with the parents prior to participating in the experimental portion of the study. The screening will determine suitability for the study. Inclusion criteria are (a) a diagnosis of autism, or PDD-NOS (Pervasive Developmental Disorder – Not Otherwise Specified). (b) IQ of 70 or above, and/or be included in general education classes for at least 50% of the school day. This school inclusion criterion helps to ensure the participant is verbal and moderately compliant to instruction. Children will be excluded from the study if they are (a) non-verbal, (b) on medication to treat aggressive behavior, (c) have a diagnosed comorbid condition that negatively impacts physical performance such as a temporary or permanent orthopedic problems, or distinct neurological disorder associated with muscle control. 

A total of 60 participants (boys and girls) in the age range of 3 to 10 years of age will be screened to participate in this study. The goal is to achieve three groups with 20 participants in each group. The groups are: Group 1 - 20 children having a diagnosis of Autism Spectrum Disorder (ASD); Group 2 - 20 neurotypical siblings of children with ASD, and Groups 3 - 20 children who serve as neurotypical controls. The neurotypical controls will be age-matched to the children with ASD.

Ethnic background: There is no requirement to match ethnic characteristics. No specific recruiting requirements are in place to recruit from specific ethnic groups.

The appendix contains the following forms:

a) Screening checklist

B. Describe the procedures for the recruitment of the participants:

Off campus recruitment of children between 3 and 10 years of age, will be conducted by methods including: (a) word-of-mouth by presentation at UTAP events, (b) the posting of flyers at doctor offices, (c) contact with families identified through databases (UTAP and ASGA). Interested families will be asked to contact the researchers to initiate inquiry into the study. The parents will be encouraged to contact the investigators if they are interested in obtaining more information about the nature of their child’s participation. In some cases, initial contact is made by phone. In these cases, the lab member making the calls identifies him or herself and affiliation with UT, confirms the identity of the party listed in the database, and ascertains the individual’s interest in hearing about the relevant study.

All participants (parents and children) will be informed that their participation is voluntary and that the choice to participate or not will not influence their present or future relationship with the University of Texas.

The appendices contain the following forms:

a) Preliminary recruiting/cover letter

b) Sample study flyer

C. Describe the procedure for obtaining informed consent.

The consent form is introduced to the parents/guardians of participants in one of three ways – by handout at UTAP events, email or upon visiting the lab (Development Motor Control Laboratory, Department of Kinesiology, Belmont 546B, The University of Texas at Austin). Upon visiting the lab, each participant parent will be presented with a copy of the consent form and assent form if appropriate. Parents of potential subjects will be given the opportunity to read the consent form and ask questions. At this time, the parents will be asked to sign the consent form. The study will be explained to all children and they will be given the opportunity to look at the equipment and ask any questions. We will seek children’s written assent by signature on the parent’s consent form. All participants, as well as their parents, will be assured that they can terminate participation at any time.

The appendix contains:
a) Parental consent form for children

D. Research Protocol:

The variability in children activity reports is very high. To assure the reliability and accuracy of the results, the children will be assessed regarding to their IQ, motor proficiency and volume of physical activity. To verify IQ scores reported by the health care provider, the Kaufman Brief Intelligence Test (K-BIT) will be utilized. It consists of two subtests: a) vocabulary which is divided in expressive and definitions and b) matrices which evaluates nonverbal skills and ability to solve problems. The assessment can be administered in 15 to 30 minutes and generates an overall composite score as well as vocabulary and matrices scores. The answers are scored 1 or 0 accordingly to correct and incorrect answers, respectively. It yields raw scores to be converted to standard scores, percentile ranks and normal curves equivalents and the results are given in age-based standard scores normed to be compared to others IQ assessments. The composite reliability mean is 0.93 and the test-retest correlation coefficient mean is 0.94 and its construct and external validity was well defined against others IQ assessments (Canivez, Neitzel, & Martin, 2005; Donovick, et al., 1996; Parker, 1993).

Two methods will be used to assess motor skills proficiency: Bruininsky-Oseretsky Test of Motor Proficiency second edition (BOT-2) and the Movement ABC second edition (M-ABC-2). The BOT-2 data will assess fine and gross motor skills such as fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, running speed and agility, upper-limb coordination and strength. The BOT-2 was chosen in this study due to the psychometrics of the study reporting high validity and reliability, as well as its usefulness in clinical settings (Bruininsky & Bruininsky, 2005). This motor skills assessment lasts approximately 45 minutes what is very important to consider when dealing with children with autistic disorder, who are well known by behavioral problems when over stimulated or when are being overwhelmed with tests. The Movement ABC is becoming the industry standard for identifying developmental coordination disorder. Using this assessment will allow us to compare our study groups to associated clinical groups. The time for this assessment is approximately 45 minutes.

The physical activity will be assessed using three methods. The first method of evaluation consists in a diary checklist reported by the parents. This checklist will help us quantify the volume of physical activity (intensity, duration and frequency) observed in children. Data from this checklist will be used to convert activity records into an estimate of energy expenditure using the metabolic equivalent (METs). Bringolf-Isler, et al. (2009) quantified the intensity and duration of physical activity and verified the “activity type/mode” in children between 6 to 14 years of age. The diary checklist has 3 levels of activity intensity (low, moderate and vigorous) and is divided in 15 min intervals from 6:00 to 23:00 hrs while the interval from 23:00 until 6:00 hrs increases to 1 hr. The parents will fill out the checklist during 1 week during the waking period.

A second method of evaluation is the use of an accelerometer. This device will be used for 1 week in the waking hours, concomitantly with the diary checklist. The accelerometer is a device, like a pedometer, clipped to a belt of waistband. This device will provide physical activity measures such as activity counts, steps taken, energy expenditure, activity levels. The combination of the activity device along with diary report has been extensively and reported in literature because it aids in establishing the validity and repeatability of diary reports. (Bouchard, et al., 1983; Bringolf-Isler, et al., 2009; Burdette, et al., 2004; Kohl, et al., 2000; O'Connor, et al., 2003; Philippaerts, et al., 2006; Sallis, et al., 1996; Telford, et al., 2004; Wrotniak, et al., 2006). A study done by O'Connor, et al. (2003) has shown highest correlation between activity indices from parent report diary and activity monitor recordings during periods after school possibly because parents usually are more aware of their child’s activity and thus their reports were more accurate. Puyau, Adolph, Vohra, & Butte (2002) validated the use of accelerometer device and compared with energy expenditure (EE) in children. They also compared different placement sites and found that the device should be as close as possible of center of body mass.
The third method of assessment will be the children’s activities recorded with a video camera during approximately two hours. The children will be videotaped doing the everyday activities at their home, such as play, draw, run or read. Video recordings will on two weekdays and one weekend day to validate the findings obtained by the parent report.

The children included in this study are in no way frail. Autism is not associated with any physiological deficit. These children are included in the general classroom, this includes the wellness/physical education program. The description of "extremely sedentary" does not accurately describe the population involved in this study. In fact, because of the frequency of co-morbid diagnoses of ADHD, these children are often hyperactive. The activities we are including are no more strenuous than the Fitnessgram that is currently mandated by the State and administered to all school children. The risks involved in this study are the risks associated with typical daily play. All tests will be administered in the presence of the parent. If an injury occurs, basic first aid will be administered (Ana Leandro – one of the researchers is CPR certified) and the parents will be directed to seek medical attention from their family physician if they believe a medical evaluation is necessary.

In summary, the BOT-2 and Movement-ABC will give a broader view of how children with ASD are developing regarding fine and gross motor skills. The parent diary report along with the accelerometer and videotape will allow us to quantify the volume of physical activity in those children. As result, the four methods together will give us a better knowledge of the characteristics and patterns of physical activity in children with ASD.

Data will be collected across 11 days, as follow:

c) Day 1- Children’s anthropometrics (height and weight) will be measured. After that, children’s IQ will be assessed using K-BIT2 and their motor skills will be assessed using BOT-2 and M-ABC-2 at Developmental Motor Control Laboratory (Bellmont 546B). The children perform motor tasks pre-established in the K-BIT, BOT-2 and M-ABC assessments. Expected time is 2 hours.

d) Days 2 to 8 – children will wear an accelerometer device (ActiGraph Model GT3X Advanced Activity Monitoring) and their parent/caregiver will complete the diary checklist during children’s waking time of each day.

e) Days 9, 10 and 11 (following week) – children’s movement activities will be recorded with a video camera during a 2 hour period on 2 weekdays and 1 day on the weekend.

The appendices contain copies of:

a) Parent diary checklist (Appendices page 17)
b) K-BIT2 – sample pictures (Appendices pages 18 – 23)
c) BOT-2 (Appendices pages 24 - 31)
d) M-ABC-2 (Appendices pages 32 - 65)

E. How will you protect the privacy and confidentiality of participants?

Parents will be asked to reveal diagnostic information about their children, and the dependent measures will include functional assessments of children. All information will be codes to remove names. Disassociating names and measurements will help to protect the privacy of participants.

A threat to privacy does exist in the recording of video data. It is possible that participant privacy may be compromised by the use of video images in publications or presentations. No names will ever be associated with the public presentation of these data. Further, the video records will be coded so that laboratory data and video records will be archived without direct identifiers on the files.

Because of the threat to privacy, a specific request for presentation of video or images from video is requested in the parental consent form.
The publication of data other than video images will exclude any information that will make it possible to identify a participant. Parents/caregiver will choose the day(s) and time(s) of video recording to better fit their schedule. In addition, participants will be given notice at least twenty-four hours prior to a researcher’s arrival at their homes. If the researcher(s) observe child abuse, confidentiality will be broken. State law requires the reporting of abuse to relevant agencies such as Child Protective Services or the Texas Department of Family and Protective Services.

F. Discuss the procedures that will be used to maintain the confidentiality of the research data.

The Developmental Motor Control Laboratory (Belmont 546A/B/J) is a locked suite of rooms protected with security alarms. Only authorized research personnel have security code clearance. Computers and back-up electronic storage devices containing participant data are password protected with user-specific passwords assigned to laboratory personnel. All media containing participant data will be coded in a way that no identifiable information will be visible on the media. Written study records containing identifying information and the signed consent and assent forms are stored in a filing cabinet in the office of Dr. Jody L. Jensen (Bellmont 546K). Written study records containing subject specific data are marked with a subject-unique code stored separately from the identifying documents. The database linking identified information with de-identified data and video records will be maintained by Ana Leandro on a secure (password protected) laboratory computer. The screening forms of individuals who do not meet the criteria to participate in the study will be destroyed. At the conclusion of recruitment for this study, the linking database file will be moved to the locked files in Dr. Jensen’s office. Authorized persons from The University of Texas at Austin and the members of the Institutional Review Board who have the legal right to review these research records, will be provided only with de-identified data. We will protect the confidentiality of these records to the extent permitted by law.

Data archived on electronic storage media will be accessed for educational and research purposes by the investigators and authorized researchers only. The data will be archived indefinitely and may be used for future analysis. Additionally, de-identified data may be made available to other researchers in the future for educational and/or research purposes.

VII. Describe any potential risks (physical, psychological, social, legal, or other) and assess their likelihood and seriousness.

There are no known risks for the participants in this study. This is an observational study. Parents and children may choose to discontinue participation at any time during the study.

While under observation it is possible that some children will become tired or fussy. This study is an observational study, thus participants are not required to continue any activity, and will, in fact, direct their own activity. Parents will be present while their children are being observed. The parents can request that observation be ended at any time.

There is the potential risk that during the observation of children’s activity child abuse may be observed. We believe that this risk is minimized by the following factors:

a) We are observing play activity of the children. While the play activities may involve the parent, the nature of play minimizes the occasion of discipline.

b) Our participant children on the spectrum are classified as having mild to moderate autism and are not classified as aggressive, thus no likely necessitating strong behavioral control measures by parents.
c) Parents will be informed that observations of child abuse will necessitate the reporting of the abuse behavior as such behavior is not protected by the data confidentiality agreement.

There is the potential risk of physical injury during a child’s play activity. This risk is judged to be no greater than the daily potential risk experienced by any child during their normal daily activities. As this study is an observational study, no activities are being requested or directed by study personnel. Thus participation in the study does not exacerbate the potential for physical injury. If a physical injury were to occur during the presence of study personnel, the researcher would participate in first aid as instructed by the parent. No observations of the child will happen without the parent present in the home. Any physical injury sustained by a child during observation would be reported to the IRB within 24 hours of the incident and a follow-up call to the family would occur within 48 hours of the incident to inquire about the status of the child.

Throughout the study, the researchers will notify participants of new information that may become available and that might affect their decision to remain in the study.

VIII. Describe and assess the potential benefits to be gained by participants (if any) and the benefits that may accrue to society in general as a result of the planned work. Discuss the risks in relation to the anticipated benefits to the participants and to society.

No direct benefits are promised for individuals or families participating in this study. Study results, in aggregate form, will be provided to participants. This information may be useful for families in modifying family activities for their children. However, such implementation would be dependent upon family initiatives and is not a guaranteed effect of study participation.

On a broader societal scale, investigations into the amount and quality of physical activity may lead to improved assessment, treatment and curricular planning for children with Autism Spectrum Disorders.

IX. Indicate the specific sites or agencies involved in the research project besides The University of Texas at Austin:

The University of Texas Autism Project (UTAP) will provide access to its database of families who have one or more children on the autism spectrum. Depending on scheduled activities, children may also be observed during UTAP activities. UTAP is an approved program initiative within the Department of Kinesiology & Health Education. Jody L. Jensen is a faculty member in the Department of Kinesiology and Health Education and is the Director of Research for the University of Texas Autism Project.

X. Review by another IRB:

This protocol is under review only by the University of Texas IRB.
Appendix E - Recruitment Flyer
We are inviting children between 5 and 10 years of age with and without Autism to participate in a study to help us understand movement skill development in children. Bring your siblings to participate as well!

Please contact:

**Ana Leandro, PT**
Graduate Student in Kinesiology,
The University of Texas at Austin
(512) 232-2686
Ana_leandro@mail.utexas.edu

**Rutvi Shah, PT**
Graduate Student in Kinesiology,
The University of Texas at Austin
(512) 232-1715
Rutvi.Shah@mail.utexas.edu

OR

**Dr. Jody L. Jensen, Director,**
Developmental Motor Control Laboratory
The University of Texas Autism Project - UTAP
(512) 232-2685
JLJ@mail.utexas.edu
Appendix F- Cover/Recruitment Letter
Dear Parent,

My name is Ana Leandro and I am a graduate student in Kinesiology & Health Education at the University of Texas. You and your child (ren) are invited to participate in a study to quantify the amount of time that children spend in play and physical activity and how this time relates to their movement skill competence. The research study is a project of The University of Texas Autism Project, under the direction of Jody L. Jensen, Ph.D. Data from this project will be used to help me complete my master’s degree thesis.

Participation in this study will involve one visit to the Developmental Motor Control Laboratory on The University of Texas campus. During this visit we will explain the study and describe how you and your child will participate. During your visit, we will take some measurements of your child’s (or children’s) physical size (e.g., weight and height), IQ and movement skills. For a period of time at home, we will ask you to have your child(ren) wear an ActiGraph – a device that will record his/her activity (the device is like a pedometer), and we will explain the diary checklist that you will be asked to complete. This visit to the laboratory will take approximately 2 hours of your time.

The second part of study will be conducted at your home during the 2 weeks following your visit to campus. In the first week, we will ask you to monitor, for 1 week, your child’s (or children’s) activity during their waking hours. This monitoring will include having your child(ren) wear the ActiGraph and during this same period, you are asked to complete an activity checklist during their waking hours. In the second week, your child(ren) will be recorded on video for a period of 2 hours after school on 2 weekdays and 2 hours on 1 weekend day of your choice.

If you and your child or children are interested in participating, please send an email to ana_leandro@mail.utexas.edu, or call at 512-232-2685. We will be happy to answer your questions and schedule your first visit to the laboratory. Parking will be made available and every attempt will be made to meet your scheduling needs.

Thank you for taking the time to read this information.

Ana Leandro, PT,
Graduate Student in Kinesiology & Health Education

Jody L. Jensen, Ph.D., Director
Director of Research, University of Texas Autism Project
Department of Kinesiology & Health Education
Bellmont Hall 222
The University of Texas at Austin
Austin, TX 78712
Appendix G- Consent forms
CONSENT FORM

Title: Physical Activity Time and Movement Skill Competence

Conducted By: Ana Leandro,
The University of Texas at Austin:
Department of Kinesiology & Health Education
Telephone: 512-232-2686
ana_leandro@mail.utexas.edu

We are inviting you and your child to participate in a research study. This form provides you with information about the study. Ana Leandro is the person in charge of this study, working under the direction of Professor Jody L. Jensen (512-232-2685; JLJ@mail.utexas.edu), Department of Kinesiology & Health Education and the Director of Research for the University of Texas Autism Project.

The purpose of this letter and our discussion today is to introduce you to this study and answer all of your questions. Please read the information below and ask any questions you might have before deciding whether or not to take part. Your participation is voluntary. You can refuse to participate without penalty or loss of benefits to which you are otherwise entitled. You can stop your participation at any time and your refusal will not impact current or future relationships with The University of Texas at Austin or The University of Texas Autism Project. If you change your mind about participation after starting the study, simply tell the researcher you wish to stop participation.

You will be given a copy of this consent letter for your records.

The purpose of this study is to determine how much physical activity children get during a typical week, and whether children diagnosed with an Autism Spectrum Disorder participate in the same amount of activity.

If you agree to be in this study, we will ask your child (or children) to:

- Come to the UT-campus and perform a variety of movement and play activities so that we can evaluate the quality of your child’s (or children’s) motor skills.
- Wear an accelerometer device (like a pedometer) during the waking hours (approximate 12 hours) for 1 week. The same week that your child wears the accelerometer, we will ask you to fill out an activity checklist, documenting the amount of time your child spends on different activities.
  Allow us to video-record your child for a period of 2 hours (usually the first 2 hours after school) during 2 weekdays (of your choice) and 1 day on weekend. During this time, we are only interested in observing your child’s regular activities. You will choose the day(s) and time(s) of video-recording to better fit your schedule. You will be noticed at least 24 hours prior to a researcher’s arrival at your home.

Total estimated time to participate in the study is approximately 2 hours for your visit to the UT Campus. During the 7 days that your child wears the ActiGraph, you are asked to keep a diary of your
child’s activity. This activity should not take more than 30 minutes of your time each day. In the second week, our visits for the purpose of videotaping will take about 6 hours of your time (3 different visits).

**Risks** of being in the study: There are no known psychological, social, or legal risks. We are observing your child during your child’s typical daily activities, thus any risk is associated with the typical activities in which your child engages.

All data will be held confidentially and where submitted to a science journal for publication, scientific conference for presentation, and in any reports made within the University of Texas, no explicit identification of individuals will be made. Participants will not be identified on record by their name or personal information. Individual records will be maintained on file, but stored in a manner that removes all personal identifiers.

**Benefits:** There are no direct benefits for individuals participating in this study.

**Confidentiality and Privacy Protections:** The data resulting from your child's participation will be maintained indefinitely, in de-identified form. Some or all of these data may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate you or your child with this or any future publication of data.

The **records** of this study will be stored securely and kept confidential. Authorized persons from The University of Texas at Austin, and members of the Institutional Review Board, have the legal right to review your child’s research records and will protect the confidentiality of those records to the extent permitted by law. All publications will exclude text information that will make it possible to identify your child as a subject, though pictures or video images in publications may make it possible to identify your child. Throughout the study, the researchers will notify you of new information that may become available and that might affect your decision to remain in the study.

If the researcher(s) observe child abuse, confidentiality will be broken. State law requires the reporting of abuse to relevant agencies such as Child Protective Services or the Texas Department of Family and Protective Services.

**Contacts and Questions:** If you have any questions about the study please ask now. If you have questions later, want additional information, or wish to withdraw your child’s participation, please call the researchers conducting the study. Their names, phone numbers, and e-mail addresses are at the top of this page. If you have questions about your child’s rights as a research participant, complaints, concerns, or questions about the research please contact **James Wilson, Ph.D., Vice-Chair, The University of Texas at Austin Institutional Review Board for the** Protection of Human Subjects at (512) 471 6978 or the Office of Research Support at (512) 471-8871 or email: orsc@uts.cc.utexas.edu.

You may keep the copy of this consent form.
You are making a decision about allowing your child or children, to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow your child, or children, participate in the study. If you later decide that you wish to withdraw your permission for participation in the study, simply tell me. You may discontinue participation at any time.

Printed Name of Child

Date of Birth

Printed Name of Child (if applicable)

Date of Birth

Signature of Parent(s) or Legal Guardian

Date

Signature of Investigator

Date

I give permission for pictures or images of my child to be used in public educational and research presentations, which may include publications and web page displays

Signature of Parent(s) or Legal Guardian

Date
ASSENT FORM

Physical Activity Time and Movement Skill Competence.

I agree to be in a study about how much time I spend playing and doing other activities (like reading, or watching TV). This study was explained to my parents and they said that I could be in the study.

In the study I will be asked to do some activities like draw and run while other people watch me. I will wear a little device, like a pedometer, that will count my movements. I will wear this device for 3 days. On 3 other days, people will take a video of me as I play and do other things that I normally do at home.

Writing my name on this page means that this letter was read (by me/to me) and that I agree to be in the study. I know what I will be asked to do in the study. If I decide to stop being in the study, all I have to do is tell the person in charge.

__________________________________________  __________________
Child's Signature                                             Date

__________________________________________  __________________
Child's Signature (if applicable)                           Date

__________________________________________  __________________
Child's Signature (if applicable)                           Date

__________________________________________  __________________
Signature of Researcher                                    Date

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Appendix H- Accelerometer Guidelines
Dear participant,

This is the week we will be measuring your child’s (or children’s) physical activity. The materials enclosed will help us become aware of your child’s (children’s) physical activity levels for 7 days. There are two items in this packet to assist you: (1) an Actigraph© accelerometer and (2) a parent- reported diary checklist (7 copies – a copy for each day).

Your children should begin wearing the accelerometer from the moment they wake up in the morning. To use it, pin the accelerometer pins close to the waistline in your children. Once pinned to the pants, you and your child do not need to do anything else. The microchip inside the box keeps time and records your child’s activity. Your child only needs to put it on and keep it on all day and take it off when going to sleep. There are a few exceptions:

1. **Please do not wear the accelerometer in the shower, bathtub, or swimming pool.** They are not waterproof.
2. **Please do not shake or tap the accelerometer.** Shaking or tapping the accelerometer will give us inaccurate information regarding your child’s physical activity for the day.
3. **Please make a note if your child moves the pants,** for example to go to the bathroom, so then we will know what to expect when we check the accelerometer recordings.

Each day you will record whatever your child is doing every 15 minutes. We will need to know the type of activity (i.e., playing basketball, walking the dog, sitting down and reading) that your child did, at what time and for how long. For that, simply go to the diary checklist and fill the block correspondent to the activity that was done during the respective period of time.

Thank you for your cooperation!

Sincerely,

**Ana Carolina M. Leandro, PT**  
*The University of Texas at Austin*  
*Movement Science Graduate Student*
Bibliography


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VITA

Ana Carolina M. Leandro was born in Sao Paulo, Brazil. After completing her work at Colegio Cardeal Motta (High School), Sao Paulo, Brazil, she entered Universidade Cidade de Sao Paulo (UNICID) and graduated as a physical therapist after 4 years (Jan 2000 – Dec 2003). During the following years she was employed as a physical therapist at Urgetrauma Physical Therapy Clinic, Brazil. In January 2006 she moved to United States. She entered the Graduate School at The University of Texas at Austin in fall 2007.

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E-mail: acmleandro@hotmail.com

This thesis was typed by the author.